Methodological Issues for Estimating the Total Value of the Rehabilitation of Mining Fields: the Case of S. Domingo's Mine

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Abstract **- The rehabilitation of abandoned mining fields is perceived by locals as of great value for nurturing the sustainable development of socio-economically depressed regions, as it is characteristic of regions home to abandoned mines. One way of contributing towards the success of such rehabilitation projects is to evaluate their total economic value. In this paper we discuss the use of a contingent valuation methodology as the most appropriate to estimate the total economic value that the rehabilitation of the abandoned S. Domingos Mine will generate. We seek to provide a preliminary discussion of some key aspects essential to design a convincing stated preference methodological framework, enabling us to further estimate a valid and reliable money measure for the total benefits of the rehabilitation process. Such money measure should be an additional incentive towards the commitment of local authorities and stakeholders towards the project and the overall acceptance and recognition of its environmental and social value by society (besides the more obvious market economic value). Furthermore, the elicitation of the non-market benefits of the rehabilitation can be used subsequently for a Cost-Benefit Analysis, enabling public authorities to take truly sustainable local development decisions promoting development in accordance with the Triple-Bottom-Line framework.**

Key Words -*Contingent Valuation; Mine; Non-Marketed Benefits; Rehabilitation.*

JEL classifications: Q51, Q56, R58.

1. Introduction

Governments are often left with liabilities for abandoned mine rehabilitation because the effective process of such contaminated sites implies expensive undertakings, complex technological solutions, the involvement of local authorities and the input of many other differentiated stakeholders, and the acceptance and recognition of the rehabilitation project by society. Overall, rehabilitation is perceived by locals as of great value for nurturing the sustainable development of socio-economically depressed regions, given this represents a characteristic of many regions home to abandoned mines. The success of such rehabilitation projects definitely depends on the overall acceptance and recognition of their total economic and social value by society in conjunction with the commitment of local authorities and other stakeholders. One way of contributing to a successful outcome is estimating all the monetary benefits, particularly non-marketed social and environmental benefits, generated by rehabilitation projects for such contaminated sites. In this paper, we propose and discuss some key preliminary questions for using a contingent valuation methodology to estimate the non-market benefits of the abandoned S. Domingos mine rehabilitation project. We begin by characterizing the scope of intervention, defining the rehabilitation project and the marketed and non-marketed benefits that are expected following successful project implementation. Furthermore, the theoretical monetary measure for non-marketed social and environmental benefits is ascertained and an empirical methodology for its estimation is proposed. A contingent valuation stated preference approach seems most appropriate for this purpose. After a literature review of the empirical applications of stated preference approaches for valuing the benefits of abandoned mine field projects, the main steps necessary to apply a contingent valuation to the S. Domingos Mine rehabilitation project are set out. For each step, particular aspects emerging from the empirical application to the S. Domingos Mine are discussed with some solutions put forward for more effective empirical application. We expect to obtain a convincing preliminary stated preference methodological framework that will further enable us to estimate a monetary measure for the non-market social and environmental benefits that the S. Domingos rehabilitation project will provide. This monetary measure represents an additional incentive towards the commitment of local authorities and stakeholders to the project and the overall acceptance and recognition of its environmental and social value by society (besides the more obvious economic value). In addition, the monetary environmental and social benefits

can be used for an eventual Cost-Benefit Analysis phase of the rehabilitation project thus helping public authorities take truly sustainable decisions and thereby promote real sustainable local development. After this Introduction, in the Experimental Part, we first characterize the scope of intervention and define the rehabilitation plan. Then the overall expected benefits will be ranked and stakeholders' perceptions presented. Finally, the expected rehabilitation benefits will be linked with the concepts of welfare and total economic value, in order to define the monetary money measure that will be used to evaluate the value that society attributes to non-market benefits of the rehabilitation plan. In *Results and Discussion* we defend the Contingent Valuation Method as the most adequate valuation technique for estimating the plan's rehabilitation value and describe the methodological steps before discussing some preliminary aspects arising from its application to the particular context of S. Domingos Mine. Finally, we present our conclusions.

2. Experimental Part

One must be aware that the task of getting a money measure for measuring the impacts that a mine rehabilitation project causes on local welfare is not straightforward. Firstly because there are several rehabilitation actions implemented in different time periods and not only one. The actions will be applied to a significantly large and environmentally degraded area, triggering a network of impacts that will cause changes in the ecosystem and related functions. These environmental improvements will create new development opportunities to the local populations, thus enhancing local social welfare. Changes in the local population's welfare will be triggered by the benefits generated by the uses that local society will make of the rehabilitated mining area. Some of these benefits are easier to evaluate because they are market based. Non-market benefits on the other hand, despite being sometimes far more important than the former, are more difficult to monetize. In order to get a money measure of the changes in local welfare generated by the rehabilitation plan, several phases must be accomplished, such as: the characterization of the intervention area and the definition of the rehabilitation plan; the description of the benefits that the rehabilitation plan is supposed to generate and the assessment of the perception that the stakeholders have over them; the design of a linkage between those benefits, the social welfare, and a theoretical money measure which enables their measurement in monetary terms; and finally, the definition of a valuation technique enabling the estimation of the non-marketed benefits.

2.1 The Intervention Area: S. Domingos Mine

The São Domingos Mine is located in the Baixo Alentejo region in southern Portugal, on the left bank of the Guadiana River (Figure 1). It is surrounded by three remarkable urban centers: the cities of Mértola (17 km), Beja (district center, 65 km) and Serpa (36 km). It is close to the Spanish frontier and not far from the touristic region of the Algarve (136 km), Évora (UNESCO heritage – 142 km), and Europe's largest artificial lake, the Alqueva Dam (81 km). The entire area occupies 450 hectares, equivalent to approximately 450 football pitches. S. Domingos occupies a valley that extends from the Tapada Grande and Tapada Pequena dams, passing at the confluence with the Mosteirão river, and reaching as far as the Pomarão harbor on the Guadiana River (Figure 2)

Figure 1. S. Domingos Mine location

The soil is thin and shale is abundant. The climate is Mediterranean, with long, luminous, hot and dry summers with temperatures rising to more than 35º Celsius, and slightly rainy, soft and short winters. Geologically the S. Domingos Mine is at the heart of the Iberian Pyrite Belt (IPB). The IPB extends from Spain across the entire Baixo Alentejo region. The IPB is classified as a Metallogenetic Province[1] and a member of the European Network of Mining Regions[2]. The main S. Domingos

output was copper and the processing of cupriferous pyrite as a basic source of sulphur (Sardinha et al 2010). Historically, the operation of the mine is very ancient dating from the Chalcolithic Age (the Copper Age) more than 4,000 years ago through to 1966 when it was abandoned due to ore depletion (Batista 2004). The first period of excavation occurred perhaps during the Copper Age by the Carthaginians and Phoenicians.

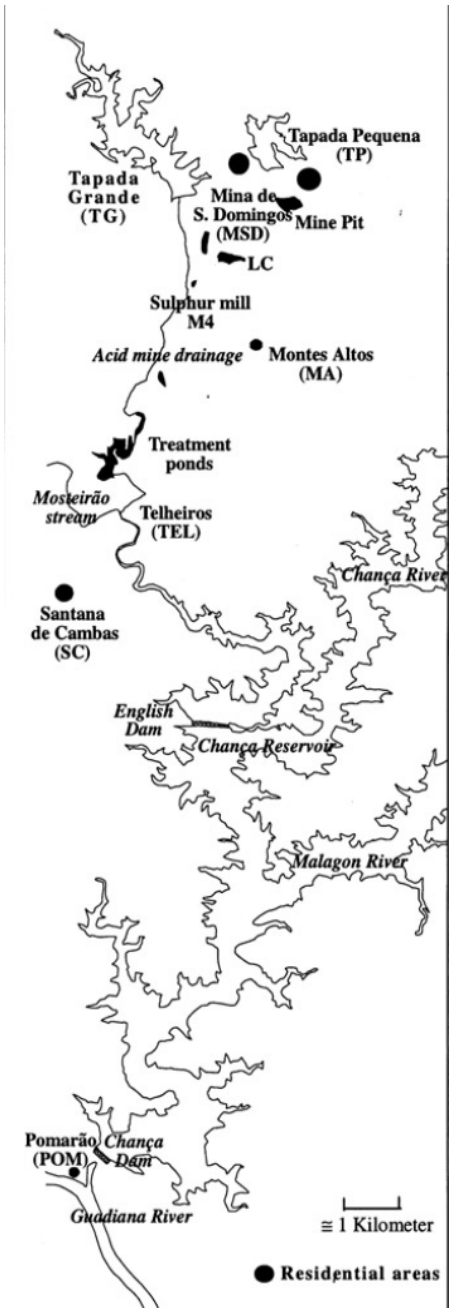


Figure 2. S. Domingos Mine Area Map[Pereira et al 2004]

The second is the Roman period where the production of copper was intensified on a large scale. Romans engaged in intensive exploitation operations for over 385 years (12-397 AD) and using ore extraction technologies that significantly altered the environment and the landscape of the region. (Alarcão 1988) refers to one of these technologies, the *ruinamontium*, described by Pliny. The technology consisted of damming a large quantity of water. From time to time, the dam was opened and the water frenetically gushed out along gullies and galleries or over rock previously partially disassembled. The strength of the water dislodged the rock by throwing stone against stone and thus causing the takedown of large quantities of rock. Two different extraction processes were used. The first comprehended open pit exploitation by means of a single cut (the *corta*). The *corta* covers an area of 42,000 m^2 to a depth of 120m from where 3 million m^3 of soil was removed. This operation ceased in the 1880s. The second was an underground extraction process involving a network of galleries and wells were dug. The wells, located at about 400m below the level of superficial circulation, were used to suck contaminated air from the interior of the mine. The copper and pyrite extracted was transported to the treatment factory in Achada do Gamo. Extraction was not the only activity at the S. Domingos mine. Incineration processes in closed ovens were used to extract sulphuric acid.

Closed ovens were used instead of open pit incineration process (as in Rio Tinto), in an attempt to avoid the disastrous environmental damages caused by the emission of highly toxic gases like SO_2, As and Sb to the fauna and flora of the region as well as compensation paid to owners of polluted fields (Baptista 2004).

Associated with the mining works, several facilities were built including an autonomous new mining village - S. Domingos - clean water reservoirs, cementation tanks, sulphur factories, a network of channels for the evaporation of acid waters, a railway to transport the ore and a harbor (Pomarão) on the Guadiana River. The new urban center was built for the thousands of workers employed by the mining complex. It included a market, several food stores, a church, a hospital and one pharmacy, a cemetery, police and military headquarters, management housing,stables and barns.The railway was the second ever built in Portugal and it was disassembled after the mine's closure. Along the 15 km of railway line, several workshops were built to supply the train with coal and water, together with several railway stations including S. Domingos Mine, Moitinha, Achada do Gamo, Telheiro, Santana de Cambas, dos Bens, Salgueiros and Pomarão, the latter near the harbor. Also built were four kilometers of tunnels, embankments, many small culverts and aqueducts in what constituted one of the most important investments ever made in the region. S. Domingos became a big, autonomous industrial village, and the biggest Portuguese mining company. It was to become the most important employer in the entire Alentejo, revolutionizing the region social-economically and profoundly affecting the regional development of that time. Located in a region with a very low density population, no other relevant economic activities apart from low income agriculture, fishing and smuggling, S. Domingos became an influential industrial centre and the biggest Portuguese mining company.

The mine's closure in the 1960s constituted a severe blow for the region. Currently, S. Domingos is subject to

extensive desertification, with an incipient level of economic activity and an aging resident community with some social problems. The current mine landscape strongly reflects the impact of alterations produced by industrial exploitation over a period in excess of a millennium. Besides some well conserved facilities like the manager's houses, the English palace, the church and the worker's houses, the area is sprinkled with ruins. From the environmental point of view, the current S. Domingos landscape is a unique portrait of the consequences of the intensive extraction and treatment of 25 million tons of ore for over a century. Waste mining materials like slag heaps and smelting ashes are spread across the area. The mining wastes are estimated to be around 32 Mton and contain toxic substances including Zn, Pb, Sb, Cu, As, Hg and Cd (Alvarez-Valero et al 2008). Several open slag dumps surround many of the ruined infrastructures. The waste mining material types take on fundamental importance because of the particular chemical characteristics of IPB ores. These undergo through sulphide oxidation processes accelerated by contact with water, leading to the production of highly concentrated acid fluids (or acid mining drainage – AMD) (Batista 2004). This AMD disperses in water, soils, and sediments, giving rise to high levels of ecosystem contamination. All around the industrial areas of Achada do Gamo and Moitinha, several lagoons were dug by miners to enable slag from the mine to settle. The S. Domingos brook, the principal water stream in the area, flows from the S. Domingos mine through the slag dumps and tailings, originating the AMD and carrying it into the Chança dam, whose waters are used for human consumption and irrigation. In spite of the dangerous environmental impact the extinguished mine poses to the environment, the fact is that the type of mining exploitation undertaken in S. Domingos, combined with the waste mining materials deposited and associated contamination, combine to form a very particular industrial landscape of unique characteristics and potential.

2.2 The S. Domingos Mine Rehabilitation Project

The S. Domingos Mine represents an important Portuguese cultural heritage both because of its long historical past and especially its more recent industrial legacy of the last 150 years. The large area covered by the mine, the mining processes used to extract the ore (pyrite, copper, zinc, blende, chalcopyrite and galena) and to produce sulphur, gave rise to an uncommon industrial landscape. The particularities of the environmental landscape, the ruins of the industrial mining complex, together with the characteristics of the S. Domingos urban centre, denote great potential for cultural tourism activities (for more detailed information, see Sardinha et al (2010)). This potential is even greater should we consider the privileged geographical location of S. Domingos. It is very close to three important urban centers (Mértola, Serpa, Beja), near Évora (UNESCO's World Heritage) and the Algarve, 200km from Sevilla (Spain) and250km from the capital (Lisbon). It is integrated into the Guadiana Natural Park and not far from either the Alqueva Dam or the Natural Park of Costa Vicentina (located by the Atlantic Ocean, in the southwest of Portugal). The size of the area has the potential for generating substantial direct economic benefits like new short-run and long-run jobs in economic sectors increasingly in demand in global markets, as is the case with tourism based activities.

Any income generated by new jobs will circulate throughout the Alentejo economy, creating new secondary jobs, improving and strengthening the diversification of the regional economy. The increasing economic performance will add to tax revenues for local and regional governments and overall earnings as well. Despite its recognized potential, the area has not been yet submitted to a sustainable development plan integrating the three main vectors of a triple-bottom line based sustainable development strategy including environmental remediation, social improvement, and economic growth.

In Portugal, the state was held accountable for the rehabilitation of abandoned mine-fields including S. Domingos. *Rehabilitation* "seeks to repair damaged or blocked ecosystem functions, with the primary goal of raising ecosystem productivity for the benefit of local people" (Aronson *et al* 1993). It differs from Restoration (both in *sensu strictu* as defined by the Society for Ecological Restoration or in *sensu lato* as defined in Aronson, J. *et al*, (1993) in that the last one seeks to conserve or recover the ecosystem structure and dynamics to its initial state previous to the human intervention. Ecosystem rehabilitation is therefore the process of restoring the ecosystem's functions and components lost due to human activities or natural disasters, but without seeking to recover the original ecosystem state. To implement the rehabilitation actions projected, the Portuguese state created a state-owned enterprise –EDM – and granted it a concession for the design and implement of the environmental rehabilitation that may lead to socio-economic enhancement of the existent abandoned mining fields. The environmental rehabilitation that EDM wants to carry out in S. Domingos is based on one main aim: the environmental rehabilitation of the former industrial zone, which EDM expects will also contribute indirectly to the social-cultural requalification of the entire S. Domingos area, including the existing urban zone, by creating the momentum that promote actions that can stimulate the appearance of parallel projects with positive impacts. The area of intervention is the overall 450ha area occupied by S. Domingos Mine.

In light of the technical appraisal produced by EDM thus far, the minimization of acid effluents will combine cost-efficient environmental and landscape rehabilitation actions. Those actions will include the rehabilitation of the drainage system and associated soils, the reforestation of some areas, the confinement of heaps, the implementation of a system for the treatment of acid mine drainage and for environmental monitoring.

A first intervention phase has already taken place in 2004/2005 in which areas of greatest accident risk were

closed off and signaled. It is easy to conclude that should the EDM's rehabilitation succeed positive changes in the local ecosystem's functions and related landscape are to be expected. These should also generate additional benefits to society, thus, EDM's rehabilitation program may generate a local Pareto improvement. Considering the extent of the intervention area and the characteristics of the EDM's rehabilitation plan, one can count on benefits of different sorts, impacting on different stakeholders located in different geographical locations. Table 1 summarizes and categorizes the general bundle of benefits that are expected to arise from the EDM's rehabilitation of the ecosystems damaged by the mining activities, by applying the ecosystem[3] service typology defined by the Millennium Ecosystem Assessment (MEA 2005), considered to be the most appropriate for our purposes[4]. But other types of classification were also added (Haines-Young, R. et al, 2009), to complement the MEA typology. Throughout this article, we generically refer to the S. Domingos mining area as an ecosystem heavily operated on by man and where the environment, landscape, and material signs of human activity deeply interact to constitute a single environmental and cultural unit.

Accordingly to Table 1, the MEA defines ecosystem services as the social benefits provided by ecosystems. Such benefits are classified into four categories: provisioning services; regulating services; habitat services; and cultural and amenity services. Provisioning services refer to the tangible, material outputs from the ecosystem that society uses in different manners: as food (fish, plants, game, and fruits), water (for drinking, irrigation, cooling, leisure, and water transport), raw material (fibers, timber, fuel wood, fertilizer, and fodder), genetic and medicinal resources (for crop improvement, medicinal purposes, or research), ornamental uses, education, and research resources. Regulating services are those produced by the ecosystem itself, functioning to guarantee its own survival and resilience. Besides such living supporting benefits, regulating services act as regulators of the quality of the air, soil fertility and water purification, and by providing flood and disease control, waste treatment, and others. Habitat services sustain the overall ecosystem services. Ecosystem functions that supply provisioning and regulating services are the same as those providing the living conditions that support ecosystem biodiversity including human ways of life. Finally, cultural and amenity services include the aesthetic, spiritual, and psychological non-material benefits people obtain from contact with the ecosystem's landscapes and those related with recreation and touristic activities.

The environmental rehabilitation of areas spoiled by earlier mining involves a range of actions that manipulate the ecosystem in such a way that ecosystem's functions and related services may be gradually improved. In the current project phase, we do not have the information to categorize exactly which of the S. Domingos ecosystem services will be affected by the EDM rehabilitation program, nor the physical dimension of the impacts. Nevertheless, we believe we can say that the rehabilitation plan will have a positive local impact and so improvements to S. Domingos ecosystem services are to be expected. The expected first positive impacts effects will be environmental, enhanced by the control of the soil and water pollution (first column of Table 1). Actions such as the drainage system and associated soil works, the confinement of heaps, and the implementation of a system for the treatment of acid mine drainage may positively contribute to improving services like: water provisioning; erosion prevention; recovering soil fertility; to improving biological control. The expected second positive effects are related with the previous. Pollution control together with the reforestation action, may contribute to enhance the landscape and to rehabilitate the indigenous fauna and flora, thus creating conditions to meliorate the supply of: provisioning services (food, raw materials, genetic, medicinal, or ornamental resources); regulating services (pollination); habitat services. Social, cultural and economic effects are to be expected. Some may be direct and arise simply from the enjoyment of the peculiar S. Domingos landscape like recreation, aesthetic enjoyment, or cultural experiences. Others like touristic activities will be dependent from local initiatives for designing and implementing cultural projects like a museum site related with archeology, or the rehabilitation of the remaining railway for tourism purposes.

Environmental rehabilitation plans for large spoiled areas by early mining similar to that of EDM, will positively affect many different people and both public and private entities. The following methodological step will be the identification, enumeration, and characterization of stakeholders' perceptions towards the rehabilitation plan. Relevant stakeholders[5] were identified by the research team and questioned about what they expect from the rehabilitation plan, using semi-structured interviews. The summary of the contents of these interviews are presented in Table 2 where stakeholders are organized by groups using a sustainable development framework (Sardinha et al. 2013), and where it is possible to see the topics which they mentioned more frequently and consider of greater concern.

In the environmental rehabilitation dimension, the water and soil quality is the concern more frequent in all the groups, while landscape as a space appears to be more relevant for interest groups and for end-users. The cultural regeneration dimension is another of the issues most addressed within the regulatory entities, interest groups and expert groups.

Considering the social revalorization dimension, the category livability stands out, especially among the regulatory entities and end-user groups and the public safety appears to be more important to the regulatory entities and to some interest groups. It is also possible to see that the economic revitalization dimension is referred by all stakeholders owing to the widespread perception of the potential of tourism to become an emergent driving economic activity. Many other institutions and people are going to be affected to a greater or lesser extent by the rehabilitation of the S. Domingos mining area. For instance, the local and regional populations might benefit

from usage of the mining area for tourism and cultural purposes. These economic activities will create jobs, wealth, and retain population. Cultural based tourism enables the improvement of infrastructures and the integration of the local population. Locals will also benefit indirectly from the improvement in regulation ecosystem services: a better environment improves property values, enhancing the ability of local economic interests to locate businesses and raise families.

Table 1. Typology of ecosystem's services potentially generated by the rehabilitation program

EDM's rehabilitation project [Sardinha et al 2010]	Types of Ecosystem Services that may be affected directly by the intervention	Types of Ecosystem Services that may be affected indirectly by the intervention
Environmental Rehabilitation actions Rehabilitation of the drainage system and associated soils; Reforestation of 250 ha; Confinement of heaps; Implementation of a system for the treatment of acid mine drainage. ⇩ Moderation of the water pollution effects; Moderation of the soil pollution effects.	Provisioning Services Water	Provisioning Services Food Raw Materials Genetic Resources Medicinal Resources Ornamental Resources
	Regulating Services Contribution to the recovering of the hydrological net functions; Contribution to erosion prevention; Contribution to recovering soil fertility; Contribution to improving biological control.	Regulating Services Contribution to improving pollination
		Habitat Services Contribution to improving Life Cycle of Migratory Species; Contribution to improving genetic diversity.
Social Cultural Promotion actions: Build an environmental interpretation centre	Cultural, Amenity Services Aesthetic Information Opportunities for Recreation Inspiration for Culture, Art and Design Spiritual Experience Information for Cognitive Development Education and Research	Cultural, Amenity Services: strengthening and improvement Aesthetic Enjoyment Opportunities for Recreation and Tourism Inspiration for Culture, Art and Design Spiritual Experience Information for Cognitive Development Education and Research Enhancing and strengthening of social coalition

Table 2. Discursive dimensions and categories in the semi-structured interviews for each stakeholder's group and organized in accordance to the framework (Milheiras et al 2011)

	G1 (N=10) Regulatory entities	G2 (N=9) Interest groups	G3 (N=2) Property owners	G4 (N=6) Experts	G5 (N=7) End users	Total (N= 34)	%
Environmental reconversion							
Landscape as space	3	4	1	1	4	13	38,2
Water and soil quality	6	7	1	3	7	24	70,6
Biodiversity	1	2	0	1	0	4	11,8
Cultural regeneration							
Social identity	4	**7**	1	**5**	3	20	58,8
Landscape as a place	**7**	6	1	4	4	22	64,7
Cultural events	2	**4**	0	0	**4**	10	29,4
Social revalorization							
Public safety	**6**	**3**	0	1	1	11	32,4
Livability/?	**7**	**4**	**1**	**1**	**5**	17	50,0
Education/?	0	1	0	2	1	4	11,8
Economic revitalization							
Multifunctional territory	3	3	1	3	4	14	41,2
Driving economic activities: tourism	**9**	**9**	2	6	7	34	100,0
Community reinforcement							
Empowerment	1	2	0	2	2	7	20,6
Ownership and responsibilities	5	7	2	1	3	18	52,9
Strategic reframing							
Integrated planning	7	6	2	6	5	26	76,5
Funding strategies	4	**2**	1	0	0	7	20,6
Territorial competitiveness	6	7	2	4	6	25	73,5

Other stakeholders such as tourists or regional governments geographically close to the S. Domingos area, including the districts of Beja and Évora as well as adjoining Spanish entities, can also benefit from mine rehabilitation. The diagram in Figure 3 clarifies the relationship between the expected benefits from EDM's intervention and the components of well-being[6]. The findings reported in Table 2 allow us to conclude that the set of EDM project rehabilitation stakeholders is composed of many different individuals and organizations, some with different perspectives on what issues are more relevant to the project. This heterogeneity is not unusual in complex interventions such as that of EDM's in S. Domingos, the principal consequence associated being greater complexity in monetizing the overall expected benefits. Some may be

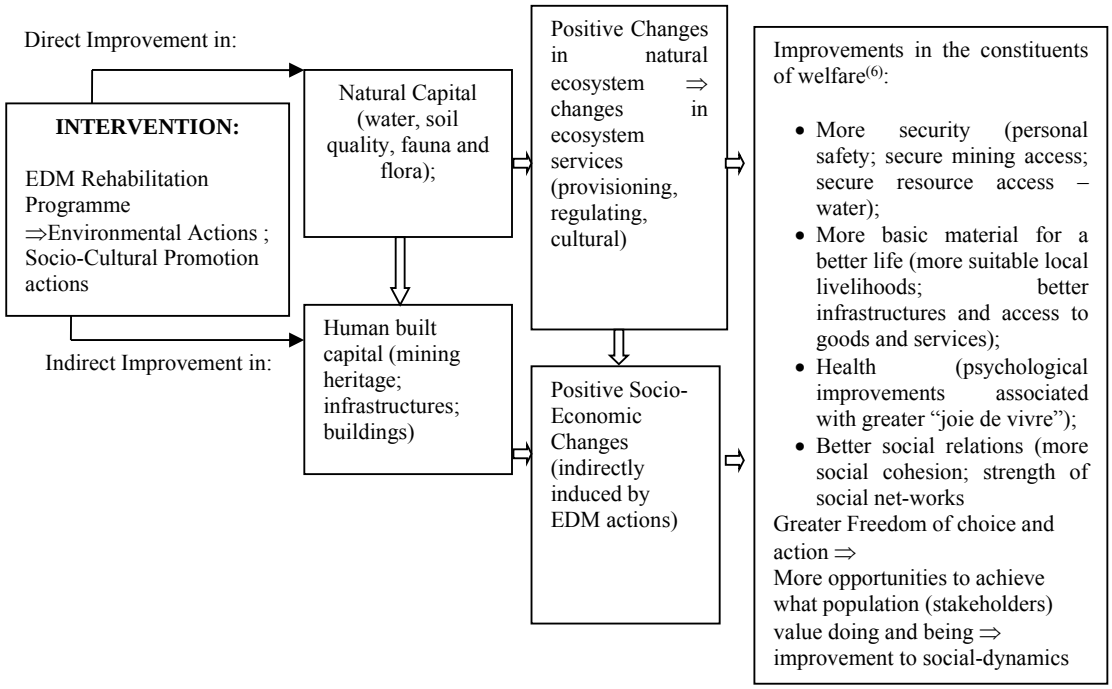


Figure 3 . The Relationship Between EDM Intervention and Welfare

generated in the short run as a direct result of the execution of the program itself; mainly economic benefits like job creation and increasing local demand for goods and services. The others are expected after the end of the requalification program. These are a fuzzy set of long run benefits differing in nature, involving various degrees of uncertainty and risk. Some of this uncertainty and risk comes from the lack of complete information as is the case with environmental rehabilitation actions. Firstly, because there is a lack of knowledge about the way they function and secondly because there is also a lack of sufficient environmental indicators to credibly quantify the real impacts of rehabilitation actions on ecosystem conditions and trends. As for the socio-economic benefits, the uncertainty and risk derive from the fact that their magnitude is highly dependent on stakeholders involvement and compliance with the main objectives of the S. Domingos Mine rehabilitation program.

3. Defining a Money Measure for the Non-Market Benefits of Rehabilitating S. Domingos Mine

Economic valuation is a way to value a wide range of individual impacts and to assess the well-being deriving from the requalification of S. Domingos. The valuation process expresses in a single unit (not necessarily, but typically a monetary unit) the disparate components of well-being, making them intelligible and comparable to the costs of intervention. As changes in utility cannot be measured, economic valuation is based on the monetary benefits arising out of usage of the environment's services.

The utilitarian based approach to evaluation ensures the value of a restored S. Domingos mining area[7] stems from a number of ways depending on how individuals engage with the mining area. The approach is based on the fact that locals may benefit (or gain satisfaction or utility) from the use of S. Domingos recovered area (including the overall built capital), either directly or indirectly, in the short run or in the long run. Although economic valuation attempts to translate benefits into monetary

units, this does not mean that marketed benefits, whose values are directly assessed through market prices, represent the only factor taken into consideration in the valuation process. On the contrary, the valuation process aims to monetize not only the benefits that enter markets but all the others that are non-marketed.

The concept of Total Economic Value (TEV) (Pearce 1993) is a framework largely deployed to disaggregate individual utility into different components of well-being and benefits. To apply TEV, ecosystem services are classified according to how they are used. TEV's taxonomy and terminology varies from analyst to analyst but broadly includes Use Values and Non-Use Values. Use values are derived from usage of ecosystem services by individuals, and Non-Use values refer to the value people may gain from knowing that the ecosystem persists even if not intending to use it either in the present or in the future.

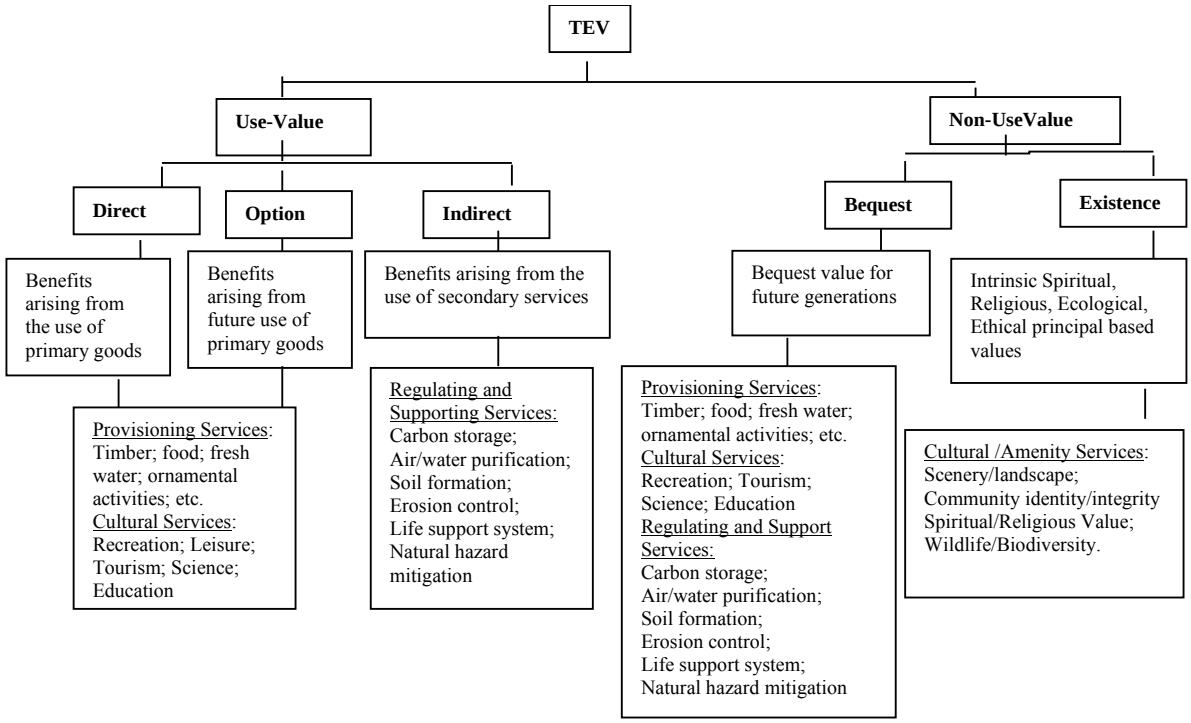
Use Values include Direct Use-Value, Indirect Use-Value and Option Value. Direct Use-Value includes the benefits from consumptive uses (either for the individual's own consumption, final consumption or intermediate production consumption) of natural resources (e.g. game, fish, timber, plants, water, etc.), and the benefits from non-consumptive uses (e.g. the enjoyment of recreational and cultural amenities, or spiritual benefits). It further includes *Vicarious Use-Value* addressing the possibility that an individual may gain satisfaction from pictures, books, or broadcasts of natural ecosystems even when not able to visit such places. Direct Use–Values broadly correspond to the Provisioning and Cultural Services MEA taxonomy (see Table 1). Indirect Use-Values include the benefits arising from the use society makes of ecosystem functions like watershed values (e.g. erosion control, local flood reduction or regulation of stream-flows) or ecological processes (e.g. fixing and recycling nutrients, soil formation, cleaning air and water, carbon sequestration). These benefits correspond to the MEA's Regulating and Supporting Services category. Finally, Option-Values derive from preserving the option of using the ecosystem's services in the future when they cannot be used in the present by oneself. The overall MEA Provisioning, Regulating and Cultural Services may be part of Option-Values where some individuals do not intend to use them in the present, but want to preserve the right to use them in the future.

Non-Use Values (or Passive Use Value) include benefits some individual may have in knowing that the ecosystem exists and persists even if they never will use it. This value category includes two other sub-categories: the Existence and the Bequest Value. The Existence value (or Intrinsic Values) reflects the moral, ethical, ecological, religious, or philosophical satisfaction felt by an individual from knowing that the ecosystem survives unrelated to current or future uses. The Bequest Value reflects the individual's altruistic satisfaction from knowing that the environment will be recovered and preserved for their heirs. Non-Use Values may be part of MEA Cultural Services. Figure 4 provides a diagram detailing the relationship between the TEV's taxonomy of use and non-use values and the MEA's services concept.

In this paper, we seek to estimate solely the monetary non-marketed benefits. This includes estimating the Cultural and Amenity services (tourism, recreation, leisure, educational, scientific, etc.) resulting from direct use, option use, bequest use and intrinsic value, and Regulating and Supporting Services. Using a broader term, we aim to estimate the non-market value of the requalification of the S. Domingos mining area. Following Hicks (Hicks, 1939) and Kaldor (Kaldor, 1939) generic economic definitions of value, the economic value of an improvement of some ecosystem and subsequent improvements in ecosystem services, is the amount of money an individual would pay or be paid to be as well off with the ecosystem or without it. Thus, economic value is an answer, mostly expressed in monetary terms (but not necessarily), to a carefully defined question in which two alternatives are being compared. The answer (the value) is very dependent on the elements incorporated into the choice, which are basically twofold: the object of choice and the circumstances of choice (Kopp R.J. et al, 1997), Following Mäller's (1971), (1974) basic model of individual utility, one can define welfare measures related with changes in the ecosystems and related services: *i.e.* where ecosystem's services are objects of choice, then a change in the quality of environmental amenities matters to the individual well-being. Such changes can be represented trough either changes in the individual preference function or in a constraint's change and they can be monetarily captured via an individual utilitarian model like the one described below.

Let $U(\boldsymbol{x}, \boldsymbol{q})$ be a well-behaved utility function of some individual affected by the rehabilitation mining project where U denotes the level of utility (satisfaction, well-being) of the individual, $\boldsymbol{x}$ is a vector of marketed

Figure 4 TEV Taxonomy and MA's Ecosystem Services (adapted from TEEB (TEEB, 2011)



goods and services, and $\boldsymbol{q}$ is a vector of non-marketed environmental and cultural benefits.

The individual wants to choose the optimal quantity $\boldsymbol{x}^*$ that maximizes his/her utility being constrained by his/her budget restriction $\sum_i p_i x_i = m_i$ where p_i is the market price of the *i* marketed good belonging to $\boldsymbol{x}$. The solution for the maximizing problem is the set of the individual's ordinary demand functions for the market goods denoted $\boldsymbol{x}^* = \boldsymbol{g}(\boldsymbol{p}, \boldsymbol{q}, \boldsymbol{m})$. Substituting the ordinary demand functions in the individual utility function, we attain the individual indirect utility function, denoted by d$U(\boldsymbol{x}, \boldsymbol{q}) = \varphi(\boldsymbol{p}, \boldsymbol{q}, \boldsymbol{m}) = U[\boldsymbol{g}(\boldsymbol{p}, \mathbf{q}, \boldsymbol{m}); \boldsymbol{q}]$. This function represents the set of maximum utility (or well-being) the individual can benefit, given his/her utility function and budget restriction.

The individual monetary measure of the change in $\boldsymbol{q}$ represents the change in the individual's utility from the initial environmental state q^0 to the final environmental state q^1, while prices and income remain constant at the initial levels. If the environment change is positive i.e. where $q^1 > q^0$ (which is what is expected from the rehabilitation of the mine area) then individual utility will rise by $\varphi^1(p^0, q^1, m^0) - \varphi^0(p^0, q^0, m^0)$. Such positive change in individual utility can be translated into monetary units through two welfare measures. These welfare measures applied to non-market transacted objects of choice, as is the case of ecosystem services, were first proposed by Mäler (1971) (1974) as an extension of the standard theory of welfare measurement related to market price changes formulated by Hicks[8].

The first measure is the maximum amount of money the individual is willing to pay to secure the improvement, i.e. the Willingness to Pay Compensated (WTP^C) money measure. This is the amount of money the individual has to pay to secure the right of having access to the additional benefits and is provided by the equation $\varphi^1(p^0, q^1, m^0 - WTP^C) = \varphi^0(p^0, q^0, m^0)$. The second measure is the minimum amount of money the individual is willing to receive to make him give up on the improvement, *i.e.* the Willingness to Accept Equivalent (WTA^E) money measure. This is the amount of money the individual wants to receive to make him/her as satisfied as he/she could be with the improvement and is given by the equation $\varphi^1(p^0, q^1, m^0) = \varphi^0(p^0, q^0, m^0 + WTA^E)$.

As we ignore the individual's utility function to attain the measures, we have to use the theoretical duality between the unknown indirect utility function and the known individual's expenditure function. The expenditure function, denoted $e(p, q, U)$, represents the minimum expenses incurred by the individual to buy a bundle of quantities of marketed products, that make him/her satisfy a previously set level of utility. Because of the aforementioned duality, $e(p, q, U) = \boldsymbol{p}\boldsymbol{h}(\boldsymbol{p}, \boldsymbol{q}, \boldsymbol{U}) = m$, where $h(p, q, U)$ is the vector of individual's compensated demand functions for the marketed products. Therefore the formulae to reach the two welfare money measures associated with an improvement in the utility associated with an improvement in $\boldsymbol{q}$, after the expenditure function are:

$$WTP^C = e(p^0, q^1, U^0) - e(p^0, q^0, U^0) = \int_{q^0}^{q^1} \frac{\partial e(p,q,U^0)}{\partial q} dq \quad (1)$$

And

$$WTA^E = e(p^0, q^1, U^1) - e(p^0, q^0, U^1) = \int_{q^0}^{q^1} \frac{\partial e(p,q,U^1)}{\partial q} dq \quad (2)$$

In equations *(1)* and *(2)* the term $\frac{\partial e(p,q,U^1)}{\partial q}$ is the derivative of the expenditure function with respect to $\boldsymbol{q}$, where $t = 0$ refers to the initial level of utility (at the current state of S. Domingos area) and $t = 1$ the final expected level of utility after the change in $\boldsymbol{q}$ (after the requalification plan). Such a derivative gives the marginal value of the change in $\boldsymbol{q}$ which is theoretically equal to the income variation that is just sufficient to maintain utility at its initial level $t = 0$ (in the case of WTP^C money measure) or final level $t = 1$ (in the case of WTA^E money measure,). Thus WTP/WTA are the fundamental, individual monetary measures in economics for non-market TEV. As changes in ecosystems provide flows of services (or of use and non-use benefits) over a time path, the TEV associated to the ecosystem improvement will be equal to the discounted sum of WTP/WTA over the individuals affected for those benefit flows instead. By applying the inter-temporal utilitarian approach just described, we may estimate the non-market TEV for the positive changes in an ecosystem generating a flow of amenities over a relevant period of time *T* by simply summing up the present value of the single-period welfare measures by the following equation:

$$TEV = \sum_{t=0}^{T} \frac{TEV^t}{(1+\rho)^t} \quad (3)$$

whose continuous version is:

$$TEV = \int_{t=0}^{T} TEV^t \, e^{-\rho t} dt \quad (4)$$

Where: ρ is a subjective rate of time preference assumed to be positive; TEV^t is the estimate of the aggregated *TEV* for the relevant affected population (*N)* by the changes at the moment *t* and is obtained so that $TEV^t = \overline{WTP}^t / \overline{WTA}^t \times N$ being $\overline{WTP}^t / \overline{WTA}^t$ the mean (or median) of individual's WTP/WTA. Having thus defined the money measure, one easily concludes that to estimate the *TEV* of the requalification plan of S. Domingos mining area after equations *(3)* or *(4)*, one must: *i)* ascertain the individual WTP/WTA for the S. Domingos change; *ii)* to choose a subjective rate of time reference - ρ ; and *iii)* to define a relevant period of time *T* during which it is assumed the change will generate social benefits to the population. In this paper, we are interested only in discussing how we can identify the individual WTP/WTA.

4. The Contingent Valuation Method (CVM)

CVM is one of the most popular valuation techniques for estimating the value of goods and services that do not exist in markets[9]. It was first described by Bowen (1943) and Ciriacy-Wantrup (1947)(1952).They propose the use of specifically structured questionnaire surveys for valuing social goods like beautification of landscape (Bowen, 1943) or collective, extra-market goods from soil conservation (Ciriacy-Wantrup, 1947, 1952). However, the first empirical work was only done by Davis (1963) one decade later. Bohm's work (1972) played a key role in demonstrating the reliability of CVM money measures; he proved that the potential strategic behavior problem arising from the aggregation over individual's benefits might not be as important as Samuelson (1954) had earlier pointed out. Further theoretical and empirical works like those of Randall (1974) (among others) developed the field over the 1970s, strongly contributing towards the improvement and acceptability of the method among academics and politicians. In 1980, the method was unreservedly recognized by the USA federal government as an important tool for supporting judicial decisions, by recognizing its use (among other valuation techniques like the Travel Cost Method, for example) for valuing the welfare changes arising from environmental disasters in the text of the *Clean Water Act* (1972) and of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) (1980). The second half of 1980s was crucial in terms of proving the credibility of CVM and its popularization in the USA and European countries. Two important works are especially credited for such popularity, Cummings et al. (1986) and Mitchell and Carson (1989) with the latter contributing towards the generalization of CVM beyond environmental economics and welfare. During the 1990s, a series of relevant environmental disasters renewed discussion over the real reliability of the valuation method. With the intention of once for all proving the reliability of the method for monetizing environmental impacts beyond any doubt, the National Oceanic and Atmospheric Administration (NOAA) asked a specifically formed committee of experts chaired by the Nobel prizes Kenneth Arrow and Robert Solo to provide their evaluation. One of the main outputs of the committee was the well Known NOAA Report (Arrow et al 1993) where CVM's credibility, validity, and reliability were clearly recognized, and a number of guidelines proposed to improve the quality of subsequent empirical applications. Currently, the method has vast applications far beyond the scope of environmental valuation impacts and is largely recognized as the only means enabling the elicitation of values for fuzzy, not well known and likely to vary across individuals (stakeholders), and services (benefits) (Borghi, 2007). Furthermore, CVM is the only existing valuation technique that generates one money measure for non-use values. Such distinctive characteristics ensure CVM is the only existing valuation technique one can apply for getting the S. Domingos rehabilitation plan's non-market monetary value. More specifically, CVM is the only method that enables us to ascertain the individual

WTP/WTA non-market values embedded in equations *(3)* and *(4)*.

Studies concerning the welfare valuation of the rehabilitation of degraded mining fields are few but all of them applied CVM or refer to this technique as being the more appropriate for eliciting the rehabilitation benefits. Examples in the literature are Damigos et al. (2003), Ahlheim et al. (2004), Damigos (2005), Lienhoop et al. (2007), Simonset et al. (2008), Strong et al. (2008), or Pemberton et al. (2010). Damigos et al. (2003) make a fairly general analysis providing information about the monetary benefits of mined land reclamation and the valuation methods that can be used for such purposes. Ahlheim et al (2004) carried out a contingent valuation approach for appraising the social benefits arising from a reclamation project of a vast landscape area destroyed by mining pits to the north of the city of Cottbus, in Brandeburg, Germany. Damigos (2005), focuses on the application of environmental valuation methods in mining. Lienhoop (2007) report a contingent valuation study to value the economic benefits of Lusatia Region, a post-mining lake-district in East Germany. Simons, et al (2008), used a CVM's probit model based approach to determine the perceptions of risk regarding airborne mine dust and radon and the effect that these perceptions had on the valuation of residential properties impacted by these substances. Pemberton et al (2010) used a CVM not to estimate the benefits triggered by some rehabilitation plan, but to estimate instead the cultural bias through the valuation of environmental resources threatened by copper mining on the island of Dominica.

CVM approaches are based on stated preferences for directly evaluating the individual's WTP/WTA for a non-market change. The basic idea of the valuation technique is to recreate a contingent, hypothetical market for eliciting individual WTP/WTA for alterations in welfare associated with any change in the quantity or quality of the environment, by simply asking people by means of questionnaires.

Therefore, CVM is basically an interview technique where the questions in the questionnaire try to recreate a hypothetical market. A classical CVM application is applied in nine steps. Firstly, a clear characterization of what we want to evaluate must be made and presented to the interviewee supported by graphical means. Secondly, the definition of the relevant population whose welfare is going to potentially change must be made. The third step deals with the simulation of the hypothetical market's basic features including: *i)* what quantity of the non-market good is going to be evaluated and what is the alternative to the proposed change; *ii)* when is the good or service going to be provisioned; *iii)* and which of the welfare monetary measures WTP or WTA is going to be used. In the four steps, the type of interview must be chosen: personal interview, telephone interview or mail interview. The fifth step deals with the sample definition and in the sixth, the questionnaire is set out. In the seventh step, interviews are held before, in the eighth step, individual answers are exploited in order to build up a consistent database. Finally, as the last step, the median or media WTA/WTP is estimated as their sensitivity to the socio-economic and demographic determinants analyzed.

The use of CVM to estimate the theoretical economic measures to quantify the TEV of non-market services has been one of the most fiercely debated issues within environmental economic valuation literature over the last twenty years. One of the most debated issues has been the validity and reliability issues to CVM welfare measure estimates, in terms of how closely they actually represent an accurate measurement of the real value. The closer the real values are to the estimated, the more accurate the valuation method is. If WTP/WTA were observable, there would be no problem. But given they are not, it is then necessary to use other complex criteria and "rules of evidence" to assess accuracy. In measurement, accuracy means the *reliability* and *validity* of data analysis used for the valuation framework [(10)]. A number of guidelines have been developed to assume CVM credibility, validity, and reliability (Portney 1994), (Arrow et al.1993), The most important are related to the presentation of adequate information over the object of choice (i.e. the environmental change), the context of choice, the choice of a credible (hypothetical) payment mechanism and the use of a referendum format. In presenting the object of choice to the interviewee, the level and type of the expected provision of the environmental attributes "with or without intervention", and if there are undamaged substitute commodities, must be presented very clearly. The researcher must previously determine which and how environmental services affect the individual's non-market value. This can be done by using techniques such as focus groups or by simply talking with the stakeholders. On defining the context of choice, it is important to explain what is the extent of the hypothetical market by informing respondents of how and when the environmental change will occur, and about the decision rules in the use for such provision e.g. if by majority vote or by individual payment.

The choice of a credible (hypothetical) payment mechanism is very important. Taxes, property taxes, sales taxes, entrance fees, changes in the market prices of goods and services or donations to special funds are the more commonly used. Finally, the referendum format is the only elicitation format that is, under certain circumstances, incentive compatible. Detractors argue that respondents provide answers inconsistent with basic assumptions of utilitarian rational choice and non-corresponding to their real WTP. Defenders acknowledge that early applications suffered from many of the problems critics have noted (see Mitchell et al 1989), however, recognition is required of how more recent and more comprehensive studies have dealt and continue to deal with those objections (see Carson et al. 2005). As a matter of fact, the CVM's welfare estimates are particularly affected by several types of biases (see for instance Mitchell et al. (1989), and Alberini et al. (2006), for a comprehensive definition of the biases and of the more current practices used in empirical research to avoid them or subtract there effects). Such biases arise from the way the CV application is applied. There are several types of biases: the choice of the true value for

the environmental change; WTP or WTA?; biases related with elicitation formats; information biases; anchoring biases; vehicle bias; hypothetical biases. Detractors argue that the existence of *embedding effects* provide answers that are not theoretically consistent. *The embedding effect* refers to several interrelated regularities in contingent valuation surveys like insensitivity to scale and scope, the sequential and sub-additive effects. These types of effects happen, firstly because welfare measures like WTP are sometimes much less dependent on the quantity of the environmental service provided than it theoretically should be (*insensitivity to scale and scope*). And secondly because, when more than one environmental service is being evaluated by the same survey, the WTP for a particular one often depends on its position in the sequence of public goods (*sequential effect*). Finally, the sum of WTP for individual changes often exceeds the WTP for a composite change in a group of public goods (*sub-additive effect*). Some CVM critics see the *embedding effect* as evidence for non-existent individual preferences for the public good but an individual *warm glow* effect instead, created by the survey process itself. In spite of all the difficulties arising from the implementation of a valuation technique as complex as CVM, the NOOA Panel recognized that the method is grounded firmly in economic theory and that CVM's welfare estimates are valid and reliable. They recommend CVM researchers to follow a set of guiding principles, defined by the Panel (Arrow et al., 1993), to guarantee the best valuation practices, theoretically consistent and empirically reliable.

5. Results and Discussion

We aim to apply a CVM approach to pursue two main objectives. Firstly, we wish to assess the induced social welfare change associated with the rehabilitation of S. Domingos's abandoned mine field; i.e., we seek to appraise whether society as a whole will be better off after the project than it was before it. And, secondly, we wish to assess the determinants of the individual's stated WTP/WTA for the rehabilitation program. We found the CVM approach to be the most appropriate because of the large project area and the sort of projected rehabilitation actions that are expected to increase the flow of several services arising from the improvement in the mining environment and in the built mining capital. The major part of the expected post-project services basically consists of non-use services such as option-values to secure the use of the mining field for development, indirect values associated with the use of secondary environment functions, values associated with direct usage of the mining environment, or non-use values. These varieties of benefits are expected to affect the welfare of many different stakeholders.

CVM is the only existing valuation technique enabling the estimation of market and non-market values affecting many different individuals with different expectations and perceptions regarding the rehabilitation mining field scenario. Our main aim is to estimate the non-market values of the rehabilitation project. To achieve the task, NOOA's guidelines are taken into consideration in order to ensure estimated welfare measurements through the CVM technique are valid and reliable by diminishing to the greatest possible extent the effects of the several sources of biases. In that CVM is mainly a questionnaire based technique, its design, the description of the contingent scenario to be valued, and the formulation of the questions related to the hypothetical market are crucial to obtaining reliable and robust results. In this section, we enumerate the several key questions we shall have to answer during the phase of questionnaire design and application in order to ensure appropriate welfare money measures for the rehabilitation of the S. Domingos mine. Table 3 summarizes those main questions. Currently, a qualitative approach is under development to characterize the stakeholders and to elicit their attitudes and opinions towards the project and further local development. These practices will allow us to understand the social and political attitudes of the populations regarding the S. Domingos Mine, the rehabilitation project itself, and the level of credibility it enjoys among locals. These are important steps previous to the questionnaire design. They provide information enabling us to identify the relevant population and to design a reliable sample; to describe the scenario that is going to be valued; to formulate the hypothetical question; and to choose a credible payment vehicle. Thus far, several existing factors have already been identified that will affect the choice of the relevant population, the sample, and the questionnaire design. First, S. Domingos inhabitants have a special and emotional attitude towards the current state of the mine. They tend to be critical about both the mine owner's and central government's role in the mine closure process. The region has economic and social issues and they look at the environmental rehabilitation of S. Domingos as an opportunity for improving the conditions and even creating a momentum that eventually leads to sustainable local development with tourism as the main activity. Most stakeholders recognize a local potential in tourism based development. Therefore, they are cautious regarding the environmental rehabilitation actions, if such actions destroy the specific and unique scenic characteristics of the S. Domingos mining landscape. To more clearly identify the impacts of the rehabilitation actions, a life-cycle assessment (LCA) is being implemented to help us identify and quantify (where possible) which are the main global environmental effects of the rehabilitation serving to define scenarios of development. There will be different direct and indirect impacts and therefore some comprehensive identification of them will be an important tool to help us in defining the contingent scenario to be valued. Several preliminary questions and conclusions may be put forward after our initial, very preliminary contacts. The first is that the relevant sample population should include not only S. Domingos inhabitants but also regional habitants from Beja District and Évora District; ideally the relevant population should include the Spanish district neighboring S. Domingos (because they are directly affected by the water pollution, and because they usually visit the region for tourism purposes), and the

Lisbon, Setúbal, and Faro Districts (potentially these are the origin regions of the tourists expected to visit S. Domingos). However, financial restrictions lead us to adopt a more conservative relevant population. The second conclusion is that the sample and the questionnaire must be constructed in such a way as to avoid a great number of protest responses. In fact, the social-economic characteristics of the research area's inhabitants and the economic crisis that currently affects the country lead us to conclude that the probability of getting a high number of NO responses to our WTP question during the phase of the questionnaire may be high. One way to decrease such probability is to previously probe the populations about: what they think of the rehabilitation project; what are their expectations towards the rehabilitation benefits; if they are willing to pay some amount to secure those benefits, how much and how long. The rehabilitation includes different actions, which will generate many different direct and indirect types of values triggered throughout different periods of time. The existence of several levels of uncertainty associated with the concretion and the dimension of those values must also be taken in to account. Besides this, the population's perception of the rehabilitation benefits may also be considered. Probably we will be forced to conclude that the rehabilitation plan generates a fuzzy set of values. Plus there is still some uncertainty amongst the population about the property rights of different entities in the Mine. If there is a fuzzy set of values, and problems with the property rights of the plan, difficulties will definitely arise with the project's acceptance by the populations, and with population's recognition of its viability and concretion.

One way to surmount such difficulties may be through the design of a contingent scenario where some entity (to whom the direct benefits of the project should be affected) will implement overall project rehabilitation (whose benefits would be generically defined in order to highlight the positive expected change in local welfare), instead of describing a complex rehabilitation scenario that might seem confusing to respondents. S. Domingos is an economically depressed region inserted in a current national context of financial crisis. That poses a problem to the definition of the vehicle of payment: taxes are certainly a concept to be avoided. An alternative should be to ask the populations whether they are willing to contribute towards a financial fund to be run by the entity that has the property rights of the project (under strict supervision by credible external entities) and exclusively attributed towards the rehabilitation of S. Domingos.

6. Conclusions

The São Domingos mine is located in the Baixo Alentejo region in southern Portugal occupying an area of 450 ha, which is equivalent to approximately 450 football pitches. The main activity was copper and the processing of cupriferous pyrite as an elementary source of sulphur. Historically, mineral extraction on this site is ancient dating from the Chalcolithic Age (the Copper Age), more than 4000 years ago, through to 1966 when it was abandoned due to ore depletion. The mine's closure constituted a severe blow for the region. Currently, S. Domingos has an incipient level of economic activity and an aging resident community. Nevertheless, local stakeholders demonstrated to be concern about revitalizing S. Domingos. From the environmental point of view, the current S. Domingos landscape is a unique portrait of the consequences of the intensive extraction and treatment of 25 million tons of ore for over a century. The waste mining materials like slag, heap dumps and tailings are spread across the area.

The waste mining materials assume great importance in the IPB because of the particular chemical characteristics. They are very unstable, giving rise to highly concentrated acid fluids dispersed in water, soils and sediments, with high levels of ecosystem contamination. In spite of the dangerous environmental impact that the extinct mine has over the environment, the fact is that the type of mining exploitation used in S. Domingos, combined with the waste mining materials deposited and associated contamination, create a very particular industrial landscape of unique characteristics and potential.

EDM is a state own enterprise held accountable by the rehabilitation of abandoned mine-fields including S. Domingos. The environmental rehabilitation that EDM wants to carry on in S. Domingos is based on one main aim: the environmental rehabilitation of the earlier extraction and industrial zone; which EDM expects will also contribute indirectly to the social-cultural requalification of the entire S. Domingos area, including the existing urban zone. Considering the extension of the intervention area and the characteristics of the rehabilitation plan, one can count with benefits of different sort, marketed and non-marketed, affecting different stakeholders located at different geographical locations. Welfare money measures are a way to value wide range of individual impacts and to assess well-being from S. Domingos's requalification. Particularly, they enable us to assess how much non-market benefits are to be generated by the rehabilitation plan (or the non-market TEV), being this our main goal. In order to assess the desired value estimate, a CVM must be applied and a number of guidelines developed to ensure as far as it will be possible the reliability and validity of the estimated money measure. For the case of S. Domingos, some particular economic, social, political, and demographic aspects are important for the design and implementation of the CV questionnaire and to guarantee data reliability.

Table 3. Questionnaire design and Implementation

Questionnaire Implementation and design		Content	Aspects to be considered	CVM Related Biases to be Avoided
Questionnaire implementation	To define the relevant population and choose the sample	Define the population that is going to be affected by the rehabilitation plan.	The reliability of the elicited values depends on the survey design elements, such as sample size and interview format	Sample Bias
Questionnaire sections	Warm-Up Questions	- Description of the survey goal: guaranteed anonymity; research purposes only; - Questions regarding the local population degree of familiarity with the problems arising from the abandoned S. Domingos mining fields (both environmental and social-economic); - Questions for appraising how informed and involved the respondents are with respect to the S. Domingos rehabilitation plan.	- The greater the level of respondent familiarity with the object of valuation, the greater the success of the CV study: more familiarity and involvement ⇒ more reliable WTP answers (Munro and Hanley, 2001); - Before undertaking the CVM study, it is important to engage in some media sessions to inform the population about the rehabilitation project; - Preparatory interviews or focus groups techniques and pre-testing of preliminary questionnaires is highly recommended.	
	The Contingent Market Scenario	- Clear, comprehensive, and short description of the object of valuation: what is to be valued (the area) and how much is it going to be enhanced (the multiple plan values: historical, scenic, ecosystem, social, development; - What is the alternative to the rehabilitation project to be valued: other rehabilitation projects with different scenarios?; the status quo? Separate rehabilitation actions that may fall under the responsibility of the mining company(1) if any, from others paid for by state funding; When will the project be finished? The project is entitled to whom?	To facilitate the design of the contingent-scenario, environmental impacts should be extensively enumerated and their effects measured whenever possible – life-cycle assessment? (2) - The same prescription for the Socio-Economic impacts. - The scenario must be read by the interviewer and illustrated with some displays containing maps, or other visual materials. - It is very important to inform respondents about the project finish date and which entities are entitled. - Pre-testing of preliminary questionnaires is highly recommended.	
	The hypothetical market mechanism explanation	Payment vehicle;	Pre-testing of preliminary questionnaires is highly recommended.	

Questionnaire sections	The Elicitation Question	- What welfare measure? WTP/WTA [3] - Open question or referendum format [3] with or without boundaries, with or without follow up question? - A "do not know" answer should be considered.	The choice of the elicitation question format depends on the financial restrictions on CV survey implementation, and between the incentive compatibility question and the efficiency level (Haab and McConnell, 2002; Freeman III, 2003).	- Hypothetical biases: this problem arises when respondents lack the incentives to reveal their true WTP ⇒ respondents should believe their opinions will be considered. - Strategic Bias: free-riding and over-pledging ⇒ to use incentive compatible question formats, like dichotomous choice or iterative bidding. - Instrumental bias: question ordering and wording; the interviewer should be neutral; • Anchoring bias;
	Additional Information	Needed to reach conclusions about result reliability: what are the determinants of elicited individual WTP?	- To be theoretically valid, elicited individual WTP should display: positive income elasticity; be positively correlated with the level of education and negatively correlated with age. - WTP is also correlated with individual attitudes: where individual consider S. Domingos rehabilitation is an exclusive task for the government or the mine company, WTP will be lowered.	

(1) Most probably, populations will not be willing to pay for actions that fall under the responsibility of the mining company.(2) If the project is going to generate a fuzzy set of different benefits, the contingent scenario to be evaluated may be a foundation. (3) NOOA Panel Recommendation.

Endnotes

(1) In accordance with the Encyclopaedia Britannica, a Mettalogenetic province is a geographic area characterized by a particular assemblage of mineral deposits or by a distinctive style of mineralization. The great belt of porphyry copper deposits that extends north from central Chile into Peru is another example of a metallogenic province.

(2) The European Network of Mining regions aims to develop a European Partnership out of regional mining region partnerships and to improve regional sustainable development strategies in mining regions http://www.enmr.org/.

(3) In biology, an ecosystem is a system that includes all living organisms (several populations of animals and plants also call biotic factors) in a specific area as well as its physical environment (the abiotic factor) on which it depends. The biotic and abiotic factors function together as a unit. Ecosystems also include humans and their interactions with the physical environment (adapted from [19]. In ecological economics, ecosystems are natural production systems, producing natural services and goods that are used by society (stakeholders) directly and indirectly, generating benefits and therefore improving social welfare.

(4) There are several typologies to classify the set of ecosystem services. See [21].

(5) By stakeholder we mean a person, group, or organization that has direct or indirect stake in an organization as they affect or are affected by the organization's actions, objectives, and policies.

(6) We used the Millennium Ecosystem Assessment definition of welfare constituents [32] [33].

(7) The Millennium Ecosystem Assessment uses the economic valuation framework to evaluate trade-offs between alternative ecosystem states, producing alternative quantities of services, resulting from alternative management decisions or human actions. Therefore, this valuation type may be policy relevant. This is one of the reasons we consider economic valuation to be an adequate framework to assess in monetary terms the rise in the welfare potentially provided by the rehabilitation of S. Domingos mining area.

(8) Analysis of this type of problem involving changes in either the quantities or the qualities of non-market environmental goods and services rather than changes in prices or income is often referred to as the *theory of choice and welfare under quantity*[23] to [27].

(9) You can get a very good picture of the theoretical and empirical history of CVM from [12].

(10) See [35] or [3] for a comprehensive description of these methodological CVM problems and their potential effect upon estimates and [19] as well.

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