

# Which monetary values for the quality of our environment? The example of pollution in the Krška kotlina alluvial aquifer in Slovenia

## Kako denarno vrednotiti kakovost našega okolja? Primer onesnaženja aluvialnega vodonosnika Krške kotline v Sloveniji

Joerg PRESTOR<sup>1</sup>, Pierre STROSSER<sup>2</sup>, Hélène BOUSCASSE<sup>3</sup>, Jure KRIVIC<sup>1</sup> & Neža ERŽEN<sup>4</sup>

<sup>1</sup>Geological Survey of Slovenia, Dimičeva ul. 14, SI-1000 Ljubljana, Slovenia; e-mail joerg.prestor@geo-zs.si;  
jure.krivic@geo-zs.si

<sup>2</sup>ACTeon, Le Chalimont, 68370 Orbey, France; e-mail pierre.strosser@wanadoo.fr

<sup>3</sup>ACTeon, Le Chalimont, 68370 Orbey, France

<sup>4</sup>Hidroinženiring, Slovenčeva 95, SI-1000 Ljubljana, Slovenia

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### Abstract

The increasing integration of economic issues into environmental policy has put the valuation of environmental goods and services at the forefront of the agenda of experts and researchers involved in the design and implementation of this policy. In the case of water, the European Union Water Framework Directive clearly indicates the need to consider environmental and resource costs in designing water pricing policies that better account for the environmental objectives of the Directive. And the assessment of environmental and resource costs is also referred to in the context of the definition of alternative environmental objectives in cases where costs of reaching the Directive's objectives are considered disproportionate or for allowing the development of new sustainable economic activities.

The paper presents the application of contingent valuation to assess the environmental costs that originate from groundwater (nitrates and pesticides) pollution in the Krško kotlina aquifer. Average willingness-to-pay values for groundwater quality improvements to stabilize groundwater quality below drinking water standards or to reduce pollution close to natural background concentrations are equal to 4,7 € and 4,8 € per household per month, respectively. The location where respondents live, their income level or their appurtenance or not to an environmental organization are independent variables that influence respondents' willingness to pay. The relatively low overall statistical significance of the regressions obtained stresses that only part of the variability of respondents' responses can be explained with the information obtained and variables considered. This is however in line with similar studies undertaken in other parts of Europe and elsewhere.

Overall, the paper demonstrates that contingent valuation is possible under Slovenian conditions. In addition to providing estimate of values of environmental costs and benefits, such contingent valuation surveys would contribute to raising people's awareness on water protection and on significant water management issues faced in Slovenia. Finally, the paper suggests continuing to test and develop different valuation methods in Slovenia for other water types (e.g. surface water) as part of the support to the implementation of the Water Framework Directive.

### Izvleček

Vedno pogostejše vključevanje ekonomskih vprašanj v okoljsko politiko postavlja vrednotenje okoljskih dobrin in storitev na prednostno listo strokovnjakov in raziskovalcev, ki so vključeni v izdelavo in izvajanje okoljske politike. Vodna direktiva Evropske skupnosti kaže jasno potrebo po opredeljevanju okoljskih stroškov in virov stroškov pri oblikovanju cenovne politike vodarine z boljšim upoštevanjem okoljskih ciljev Vodne direktive. Ocena okoljskih stroškov in stroškov virov je tudi predmet obravnave pri opredelitvi prilagojenih okoljskih ciljev, v primerih, ko so stroški za doseg ciljev Vodne direktive lahko nesorazmerno visoki ali ko gre za omogočanje razvoja novih trajnostnih ekonomskih dejavnosti.

Članek predstavlja uporabo *naključnega* vrednotenja za oceno okoljskih stroškov, ki izvirajo iz onesnaženosti podzemne vode vodonosnika Krške kotline z nitrati in pesticidi. Povprečna zneska, ki so ju gospodinjstva pripravljena mesečno plačevati za izboljšanje kakovosti podzemne vode, to je za ustalitev kakovosti podzemne vode pod

mejnimi vrednostmi standardov za pitno vodo 4,72    in za zmanj  anje onesna  enosti na naravno ozadje 4,80   . Neodvisne spremenljivke, ki vplivajo na vi  ino zneska, ki ga je anketiranec pripravljen pla  ati, so kraj bivanja, dohodek in pripadnost okoljskim organizacijam. Razmeroma nizka skupna statisti  na zna  ilnost izra  unanih regresij ka  e, da lahko s pridobljenimi informacijami in upo  tevanimi spremenljivkami pojasnimo le del raznolikosti odgovorov anketirancev. To pa se ujema tudi z rezultati podobnih   tudij v drugih delih Evrope in drugod.

  lanek ka  e, da je *naklju  no* vrednotenje v Slovenskem okolju mogo  e. Poleg pridobivanja ocen vi  ine okoljskih stro  kov in dobrobiti bi take raziskave *naklju  nega* vrednotenja dvignile zavest prebivalstva za za    to vode in za pomembna vpra  anja upravljanja z vodami v Sloveniji.   lanek tudi predlaga nadaljevanje takega na  ina vrednotenja okoljskih stro  kov in dobrobiti in predlaga nadaljnji razvoj razli  nih metod vrednotenja v Sloveniji, tudi za druge vode (na primer povr  inske), kot del podpore pri vpeljevanju Vodne direktive.

## Introduction

Comprehension of sustainable groundwater resources management in the past was strongly characterized by the uncertainties that turned it to hardly understandable category to decision makers and land users. Any human activity that represents the pressure on the environment causes certain impact. So, how to maintain the lasting status without any threat or risk for the resource? Hardly understandable sustainable principle in the past led to black and white (green) acting and maintenance of end of pipe treatment principle.

In Slovenia the average pressure from human activity is rather small owing to high portion of forest and other natural land (62,4%) and on the other side low portion of urbanized (2,6%) and agricultural areas (35%). The average population density is 96 inh./km<sup>2</sup>. Rather low step of pressures and rich groundwater resources are reasons for relatively rare water treatment facilities, limited almost to microbiological treatment and reduction of turbidity in karst water supply systems and iron/manganese reduction from intergranular aquifer water supply systems. Also the artificial recharge protection is effectuated only on two alluvial aquifer water resources in the north eastern part, on the highly agriculture and urbanized alluvial aquifer areas.

The most severe impact from the past policies on the chemical status of groundwater is evidently excessive manure usage and pesticides application. The second problem from the past policies was reaching effectiveness of protection measures and also spatial planning on vulnerable groundwater resources areas. Both these problems are still remaining, as it appears in high portion, resulting from lack of awareness of the existing pressures/impacts and use/non-use value of water.

BRUNDTLAND report's (1987) sustainability definition, Water Framework Directive (60/EC/2000) and actual progress in sustainability comprehension as entity of individual basin groundwater balance (and as a suitable combination of entropy changes and energy ("physical sustainability")) (HERMANOWICZ, 2005) are in the way to produce crucial changes from the past water resources management policy.

The actual legislation in Slovenia, adopted in last years in the frame of the WFD implementation process, significantly move the water resources management from local authority ground to water resource as a natural entity area. Fur-

thermore the actual legislation controls load to the water environment, provides monitoring of emissions and impacts, water quality standards, critical values for starting the protection measures and trend reversal, criteria for water protection areas definition, detailed risk analysis, development of water supply systems and development of river basin management plans.

To reach effective implementation of the adopted legislation and new policies, the full transfer of the above mentioned directives and actual sustainability comprehension to local level, to individual local groundwater bodies' users is still needed. Each individual hydrogeological basin water balance has to be emphasized by pressures and impacts balance in order to get reliable information of present status, use and non-use value of water and economic assessment of protection and remediation measures. Reliable information of status to the local level is crucial to significant rise of awareness and water resources economic evaluation.

The protection of the environment in general, and of water resources (including groundwater) in particular, has become in recent years increasingly questioned by economic operators directly impacted by environmental policies. Partly as a response to this questioning, the design and implementation of environmental policies are increasingly integrating economic concerns via a more systematic use of economic assessments to investigate the tradeoffs between economic development and the protection of the environment. In parallel, policy makers have shown interest in applying economic instruments (taxes, charges... such as the groundwater abstraction tax in Slovenia) in the field of environment. Such economic instruments are means to provide incentives to economic operators for more sustainable use of natural resources – but also for collating financial resources for supporting investments in environmental protection infrastructure (e.g. wastewater treatment plants). In the field of water, the recent European Union (EU) Water Framework Directive (WFD) has taken clear stock of this evolution as it integrates directly economic principles, methods and tools and instruments into water policy.

For experts involved in the management of water resources and implementation of the EU WFD, but also for policy makers, the increasing integration of economics into water policies has led to new challenges – be it in terms of processes and actors involved or in terms of methods and tools to be applied. With regards to the latter, how

to integrate environmental benefits or environmental degradation into economic analyses has received increasing attention. Indeed, it poses the question of the value of environmental goods and the possibility to estimate a monetary value for these goods (e.g. improvements in water quality) for which there is often no market and price.

### Objectives and content of the paper

The paper presents an attempt to value environmental goods (i.e. a given level of environmental quality) in monetary terms under Slovenian conditions. It summarizes one of the first experiences in the (monetary) valuation of environmental goods in this country and of the application of a specific valuation method, i.e. contingent valuation, for assessing environmental costs linked to groundwater pollution. This activity has been developed as part of a collaborative effort between the Geological Survey of the Republic of Slovenia and the Krka Pilot project – a project launched in 2004 by the Ministry of Environment and Spatial Planning of Slovenia to support *inter alia* the implementation of EU WFD in Slovenia<sup>1</sup> It has also benefited from links and input from the EU-funded BRIDGE research project that aims at proposing a sound methodology for the establishment of threshold values for pollutants in groundwater for the forthcoming EU groundwater directive.

The paper summarizes first how environmental and resource costs are considered in the EU WFD – and for which policy decisions these costs might need to be assessed. It then provides an overview of existing methods for valuing environmental costs and benefits. This overview includes a summary of the existing valuation studies available in Europe in the field of environment in general and more particularly in the field of water and groundwater resources. The paper continues by presenting the application of the contingent valuation method in the Krško kotlina aquifer (East of Slovenia). The characteristics of the aquifer and relevant methodological aspects are described, before presenting the results obtained through statistical analyses of survey data. The paper ends with some conclusions on the potential use of contingent valuation in Slovenia in particular in the context of the implementation of the WFD.

### Environmental and resource costs in the WFD

As indicated above, the EU WFD is the first piece of European legislation which promotes the integration of economic principles, methods, tools and instruments into environmental policy. In particular, the WFD requires Member States to account for environmental and resource costs (or benefits) in their water management decisions, in particular (i) to design water pricing policies that support the achievement of the environmental objectives of the directive and (ii) to justify lower environmental objectives based on the compari-

son of all (including environmental) costs and benefits.

Direct references in the WFD to environmental and resource costs include Item (38) of its preamble of that specifies that ... *The principle of recovery of the costs of water services, including environmental and resource costs associated with damage or negative impact on the aquatic environment should be taken into account in accordance with, in particular, the polluter-pays principle....* Article 9 of the WFD dealing with the recovery of the costs for water services reinforces from a legal point of view this reference as it specifies that *Member States shall account of the principle of recovery of the costs of water services, including environmental and resource costs...*

Indirect references to environmental and resource costs (or benefits) can also be found in the WFD, e.g. in its Article 4.4. (b) that refers to significantly better environmental options (implying lower environmental costs) or Article 4.7.(c) that requires Member States to compare the potential benefits of any new (morphological) modifications or economic activity with the costs to the environment that would result from this modification or activity.

The WFD, however, does not specify how environmental and resource costs should be evaluated and valued in monetary terms. Preliminary discussions among EU Member States provided some insights in existing valuation methods. They stressed however the need for additional work to better define environmental and resource costs and to make these methods operational for supporting policy decisions and the development of river basin management plans (EUROPEAN COMMISSION, 2002). Further work at EU level was then performed which main outcome is summarized in the following section.

### Valuing environmental costs – state of the art

Environmental costs can be defined as the costs of damage that water uses impose on the environment and ecosystems and on those who use this environment. Resource costs are the costs of foregone opportunities which other users suffer due to the depletion of water resources beyond their natural rate of recharge or recovery (e.g. in case of over-abstraction of groundwater) (EUROPEAN COMMISSION, 2002). Environmental and resource costs are clearly inter-related and they can not just be added one to the other. Moreover, resource costs might exist in the absence of environmental costs, e.g. if the allocation of water between users is not efficient but no pollution or depletion of the resource takes place.

Both environmental and resource costs are external costs. An external cost occurs if the activity of one agent causes a loss of welfare to another agent and if this loss of welfare is uncompensated. If the loss of welfare is compensated then it is an internal cost. For example, discharges of wastewater into a river, even if partially trea-

ted, might have negative impact on downstream water uses if for example pollution resulting from this discharges requires additional treatment for downstream uses. If financial transfers between the polluter and the affected uses take place or if pollution charges/taxes are imposed on the polluter, then the external (environmental) cost is said to be internalized. Otherwise, it is an external cost.

Resource costs are due to an economically inefficient allocation of water in terms of quantity or quality. Resource costs are equal to the net benefits for present and future uses minus the net benefits of the best alternative use (now or in the future). Estimating resource costs requires calculating environmental costs, if they are relevant and significant. In this paper, however, we focus solely on environmental costs.

Different methods are proposed for assessing environmental costs. Cost-based methods aim at obtaining a proxy of the true value of environmental costs by estimating the costs of measures & projects that would be required to prevent or mitigate current damages to the environment (for example by building additional treatment to clean polluted surface water). Benefit-based methods focus on users of the environment – and on the potential benefits these might obtained if the environment would be cleaned. A variety of methods are part of this group such as:

- The *avoided-cost* method – by estimating the costs that would be avoided by economic sectors using water if this water would be cleaned up to given standards. For example, the denitrification costs drinking water company are currently paying to treat groundwater polluted by nitrates;
- The *transport-cost* method – estimating the value of an environmental good such as a natural site by estimating the (transport, accommodation, etc) costs incurred by visitors for visiting this natural site;
- The *hedonic pricing* method – where real estate prices are correlated to different characteristics of real estates including in terms of the quality of the natural environment in which they stand. Differences in real estate prices correlated to different qualities of the natural environment helps estimating the values for these environmental qualities;
- The *contingent valuation* method – based on the construction of a hypothetical market for a given environmental good (e.g. water at a given quality) with respondents being asked through structured questionnaires to explicit their *willingness-to-pay* for this environmental good.

Under some conditions, values obtained in given locations can be used for estimating en-

vironmental costs and benefits in another location. This method also named *benefit-transfer* is only possible if the environmental goods and the general behavior of the population at both site(s) (the site where values have been developed and the site where values are to be applied) are similar.

Various examples can be extracted from literature.

• Avoided costs and contingent valuation

A benefit-based valuation was conducted in France in the Alsace region. Potash ore extraction leads to high concentration of chlorides. When public authorities became aware of the extent of the problem, measures were implemented. Measures aim at preventing any further degradation of the aquifer. In 2027, approximately 96 percent of the salt present in the aquifer in 2002 is supposed to be removed. But according to the Water-FrameWork requirements, “good status” has to be achieved by 2015. So an analysis was conducted to assess the benefits of an accelerated clean-up scenario.

For example, some water utilities have to treat water, because of the salt, in order to make it drinkable. So the benefits of an accelerated clean-up are equal to the avoided costs for drinking water firms between 2015 and 2027. It is estimated at 4.6 Millions euros. Another benefit is related with non-use value. A contingent valuation implemented in the region stated that the WTP to preserve the aquifer is equal to 61 euros per household. Taking into account the population close to the polluted area and taking into account the discount rate, we can estimate that the total non-use benefits are ranged between 17.6 and 35.2 million euros.

• Transport costs

A transport costs study was conducted to value the recreational amenities of the French storage dam “Lac de Der”<sup>2</sup>. Phone made possible 2021 interviews of users and non-users living in the municipalities near the lake, including 1477 that are part of the sample. For them two substitute sites were identified, the Orient lake and the Madine lake. 241 persons were interviewed directly on the site in November 2002. Among them 111 were included in the final sample.

The journey costs are ascribed to the distance between home and the lake, taking into account the power of the vehicle and cost per kilometer. It is divided by the number of visitors. Transport costs are also composed of opportunity costs, a function of the time needed for the journey and income.

First step is to explain number of visits thanks to transport costs, but also socio-economic cha-

	Water utilities	Households	Agriculture		Industry	Non-use value
			Corrosion	Crops		
Avoided costs	4,6	[1,2; 2,3]	0,3		NA	
Increase of production				0,6		
Contingent valuation						[17,6; 35,2]

Table 1. Summary of results for avoided costs and contingent valuation

Table 2. Summary of results for a transport costs study

	Without taking into account substitute sites		Taking into account substitute sites	
	Per visit/per person	Per year/per person	Per visit/per person	Per year/per person
Value (in euros)	38	[262 / 264]	[19 / 22]	[150 / 155]

acteristics as well as practiced activity and knowledge about the site. Then this information is used to estimate consumers' surplus with the coefficients before transport costs.

- Hedonic pricing method<sup>3</sup>

House premium due to the vicinity of a lake is about 6% is one of the conclusions of a Dutch hedonic pricing study. The period 1989–1992 was chosen to study nearly 3000 house transactions in 8 towns and estimate the effects of environmental attributes on transaction prices.

A first step was to regress house prices on structural housing attributes. The difference between this value and the actual price is considered as

resulting of differences in locality (public and environmental facilities). A location-indicator<sup>4</sup> is derived from this difference and regress on location variables.

The largest increase, up to 28 %, in house prices due to environmental factors is for houses with a garden facing water, which is connected to a sizeable lake. This figure is obtained by summing the 7 % augmentation due to the vicinity of the lake, 10 % due to a view of the lake and 11 % due to a facing garden.

Methods differ by type of information mobilized, cost of application, level of expertise. They all have advantages and disadvantages since they are designed to specific, but various, goals. Main characteristics are summarized on table 4.

	Feature	Significant	Not significant	Not tested	Premium
<i>In the residential area</i>					
<b>Green stripe</b>	View of	3 cases, n=962	3 cases, n=1442	2 cases, n=409	4%, 5%, 5%
<b>Park</b>	View of	2 cases, n=456	6 cases, n=2537		7%, 8%
	Vicinity	1 case, n=112	1 case, n=2701		6%
<b>Canal</b>	Facing garden		1 case, n=297	7 cases, n=2516	
	View of	2 cases, n=391		6 cases, n=2422	4%, 5%
<b>Lake</b>	Facing garden	2 cases, n=443		6 cases, n=2370	11%, 12%
	View of	2 cases, n=443		6 cases, n=2370	8%, 10%
	Vicinity	2 cases, n=443		6 cases, n=2370	5%, 7%
<i>Bordering of residential area</i>					
<b>Park</b>	Vicinity	1 case, n=297	3 cases, n=1031	4 cases, n=1485	12%
<b>Lake</b>	Vicinity	3 cases, n=1166		5 cases, n=1647	5%, 7%, 10%
<b>Open space</b>	View of	2 cases, n=929		6 cases, n=1884	6%, 12%
<i>Regional feature</i>					
<b>Wood</b>	Presence	2 cases, n=890		6 cases, n=1923	8%, 12%
<b>Lake</b>	Presence	1 case, n=336		7 cases, n=2477	6%
<b>Diversity of landscape types</b>	Presence	1 case, n=593		7 cases, n=2220	9%

Table 3. Summary of results for a hedonic prices study

Table 4. Summary of characteristics for the different valuation methods

	Information mobilized	Cost of application	Level of expertise	Advantages	Disadvantages
<b>Avoided costs</b>	"Technical" information	+	Engineering		- Do not elicit non-usage value - Need to make prospective
<b>Contingent valuation</b>	Sample of potential respondents (if mail questionnaire)	+++	- Sociologic (questionnaire) - Statistics - Economics (distinction between use and non-use values)	Elicit usage and non-usage values.	- Bias of questionnaires - Based on respondents answers = > subjective - Difficulties to make people understand the good they need to value
<b>Hedonic prices</b>	Data on house transaction	++	- Statistics - Real estate	Well adapted to assess the effect on welfare of a change in environment quality.	- Do not elicit non-usage value. - Difficulties in the selection of suitable data (comparable houses). - Take care of inflation effects
<b>Transport costs</b>	- Sample of potential respondents (if mail questionnaire) - Data on visit frequencies, transport costs	+++	- Statistic - Economics	Well adapted to assess recreation values.	- There might be substitute sites. - The visit might have multiple goals. - Do not elicit non-usage value.

Avoided costs require very specific information collected to experts. It can be more or less expensive, depending on the difficulty to collect it, whether it is free or not ... To implement the other methods, such knowledge is not needed, except for the definition of scenarios in contingent valuation.

Contingent valuation and transport costs methods also have an important cost price because of the time needed to construct questionnaires, send them or pay interviewers – in case of face to face interviews, and do the statistical analysis. Hedonic prices raise information about house transaction, which you may have to pay. And, as for contingent valuation and transport costs, statistical analysis is time consuming.

As a conclusion, contingent valuation seems to be one of the more expensive methods. Nevertheless, it is largely the more commonly used. Indeed, one of his main advantage is to elicit both use and non-use values. In the particular case of groundwater quality, hedonic prices and transport costs can not be used. Avoided costs could also be implemented, but as illustrated by the study on chlorides, these methods are not exclusive.

The strengths and weaknesses of each method are widely recognized. The type of environmental good to be valued (e.g. visible or not) and its current uses (e.g. by economic actors or for recreation), the location of the good (e.g. hedonic pricing best works in densely populated areas), the need to assess use and/or non-use values (see Box 1) or the policy context in which results will be used (e.g. for defining adequate levels for environmental taxes or for setting economically-efficient environmental objectives) are elements that need to be considered when choosing valuation methods. Also, methods can be used in combination in particular when more detailed assessments are required. In general, cost-based methods are more suited to cost-recovery and pricing discussions – while benefit-based methods

**Box 1.** Use and non-use values – what are they? Economic theory distinguishes between different *use values* and *non-use values* that form together the overall value of an environmental good. Use values are values related to the direct use of water for drinking, the operation of economic actors, recreation, etc, as currently taking place. They include also potential values attached to water (*option value*) because of possible alternative uses as compared to today's situation. For some existing uses, a market might exist (e.g. market for drinking water) that can help assessing use values. For others (e.g. water as part of landscape or for recreation), there might be no market and the value of the environmental good will then need to be assessed indirectly, e.g. via hedonic pricing or transport cost methods. Non-use values are linked to possible values water might have for future generations (*bequest value*) or the intrinsic value water has because it exists (*existence value*). Non-use values can only be captured with contingent valuation

can best feed into debates on the definition of environmental objectives and possible derogation or exemptions to these objectives.

Because of the importance of future policy needs in Slovenia with the definition of threshold values for pollutants in groundwater (as part of the implementation of the forthcoming EU groundwater directive), it was decided to test contingent valuation methods in an aquifer considered as *at risk* of not reaching good groundwater status by 2015. The Krško kotlina aquifer located at the downstream part of the Krka river sub-basin (East of Slovenia) was selected for this pilot test.

### Main characteristics of the Krška kotlina aquifer

The Krško kotlina aquifer occupies a part of Krško-Brežice plain between the towns of Krško, Brežice, Brod and Velika vas. The area covers about 90 km<sup>2</sup>. The average altitude of the plain is around 155 m and it ranges between 140 and 160 m.

### Geology

The Krško-Brežice basin is a tectonically formed depression. In the area of Krško plain it has been filled with alluvial sediments of the Sava river that are composed of Quaternary gravel and sand, and Pliocene sand and clay. Beneath the Pliocene strata are Miocene rocks, mostly marl. The average thickness of Quaternary sediments is about 20 m. The thickness of Pliocene sediments ranges from 0 to 600 m whereas the thickness of Miocene strata ranges from 50 to 700 m.

### Hydrogeology and hydrology

The Krško kotlina aquifer is being drained in two major directions. The part of the aquifer situated north of the Sava river is conveying underground water in southerly direction, whereas the major part of the aquifer between Sava and Krka rivers is being drained in easterly direction.

Alluvial Sava river sediments, composed of Quaternary gravel and sand, are highly permeable with their hydraulic conductivity coefficient (K) ranging from 10<sup>-5</sup> to 10<sup>-3</sup> m/s. The average K value is 2\*10<sup>-3</sup> m/s. These sediments form a regional unconfined aquifer with intergranular porosity.

The Pliocene sediments have an average hydraulic conductivity in the range of 10<sup>-8</sup> m/s. They act as an impervious barrier at the bottom of the aquifer. Miocene marl strata have even lower permeability, with the hydraulic conductivity as low as 10<sup>-9</sup> m/s.

The aquifer is recharged by infiltration and underground flow from the hills around the Krško kotlina. In the Krško town area and upstream from the Krško nuclear power plant dam the Sava river recharges the aquifer, whereas in other areas it drains the aquifer. The aquifer is also drained by the Krka river. The effect of the Sava river

stage undulation on groundwater level can be observed up to 400 m from the river. The average discharges of the Sava and Krka rivers are 290 and 55 m<sup>3</sup>/s, respectively.

The main groundwater abstractors are the Brege and Drnovo pumping stations. The average pumping rate is 90 l/s per pumping station, therefore they have a considerable influence on groundwater level.

### Precipitation and infiltration

The precipitation in the Krško kotlina and its surroundings is monitored in several hydro-meteorological stations. The average precipitation in the area is estimated between 900 and 1100 mm/y and temperature 11°C in the period from 1961 to 1990 (KLIMATOGRFIJA SLOVENIJE, 1995). The average long-term evapotranspiration in the area is estimated at 500 mm/y (PRESTOR & JANŽA, 2006). Infiltration is thus estimated at approximately 500 mm/y.

### Pressures & impacts, main abstractors

The main pressures to groundwater are nitrates and pesticides. Agricultural land represents more than 80 % of the area.

	Krška kotlina	Slovenia
Agricultural land (%)	<b>73,8</b>	35
Urbanized areas (%)	<b>8,6</b>	2,6
Forest (%)	12,8	58,2
Agricultural land + Urbanized areas (%)	<b>82,4</b>	37,6
Forest + other natural land (%)	17,6	62,4
Population (inhabitants)	6.363	1.952.528
Population density (inhab./km <sup>2</sup> )	65,7	96,3

Population density is relatively small, but lacking of waste water treatment, important part of polluted water is drained directly to the groundwater.

	Krška kotlina	Slovenia
Public road density (m/km <sup>2</sup> )	<b>683</b>	320
Railway density (m/km <sup>2</sup> )	<b>122</b>	64
Industrial waste deposits	1	27
Public waste deposits	2	58
Waste water emissions	11	579
IPPC facilities	5	170

The important pressure is also traffic, as the main traffic stream between Ljubljana and Zagreb (Slovenia and Croatia).

The alluvial aquifer with no significant cover layers is highly to extremely high vulnerable. This means that we presume that practically all pollution on the ground penetrate through the unsaturated zone to groundwater. Expected concentration of nitrates in groundwater body is relatively high (30,8 mg/l), but still below the critical value (75% of quality standard).

	Krška kotlina
N (kg/ha) average surplus	83,6
N from agricultural land (kg/ha) average surplus	78,9
Total N from urbanization (kg/ha) average surplus	3,4
Total N from other sources (kg/ha) average surplus	0,7
Expected concentration of NO <sub>3</sub> (mg/l) average value	30,8

State monitoring network showed aggregated average value 32,4 mg/l of nitrates (2003 + 2004). Upward trend was present in six years period (1999–2004).

Atrazine and desetil-atrazine are present, the first always bellow quality standard (0,024 µg/l) and with downward trend and the second (0,07 µg/l) still with upward trend. Other pesticides are sporadically and temporarily exceeding quality standards.

Tetrachloreten was exceeding quality standards in two monitoring sites (expected origin from limited areas). Ammonium and phosphates were also temporarily exceeding quality standards at several monitoring points showing the expected impact of characteristic dispersed population pollution origin.

The pressures and observed impacts on groundwater chemical status show the need to economic consideration of critical value, i.e. starting point and the last time of measures entering into operation for trend reversal, especially concerning additional protection measures.

Also very thorough economic assessment is needed for eventual spatial redistribution of additional measures that would improve the quality of groundwater which is used for water supply as close as possible to natural background.

### Developing the contingent valuation survey

The implementation of the contingent valuation survey followed a series of steps common to all socio-economic surveys (development of draft questionnaire, pre-testing<sup>5</sup>, refinement of the questionnaire, design of sampling plan, interviews, data entry and checking).

The structured questionnaire developed dealt with issues such as: introductory presentation of the context (characteristics of the aquifer, main sources of pollution, existing problems), respondent's general views on the environment, current use of groundwater and relationship to natural waters, importance of actions for restoring groundwater quality and willingness to pay for such actions, respondent's socio-economic profile and general (open) reactions and comments on the questionnaire and its content. With regards to actions for restoring groundwater, two different restoration programs were proposed to respondents in a sequential order: asking first whether respondents would be willing to support financially a program aimed at restoring drinking water quality for the aquifer and how much; and then, if their response to the first program was positive, asking them whether they would be will-

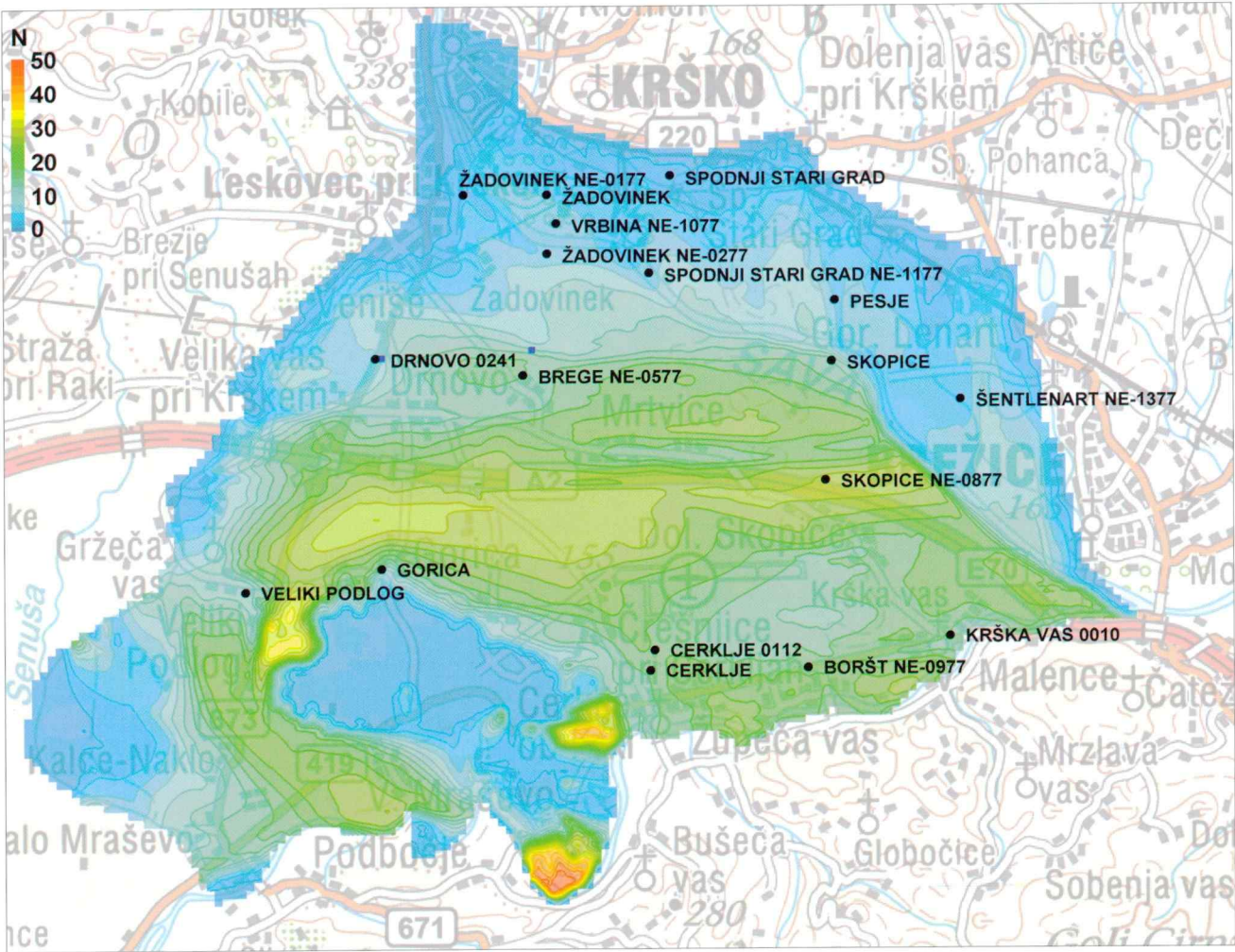


Figure 1. Numerical model of NO<sub>3</sub> (mg/l) content distribution in groundwater of Krško polje alluvial aquifer

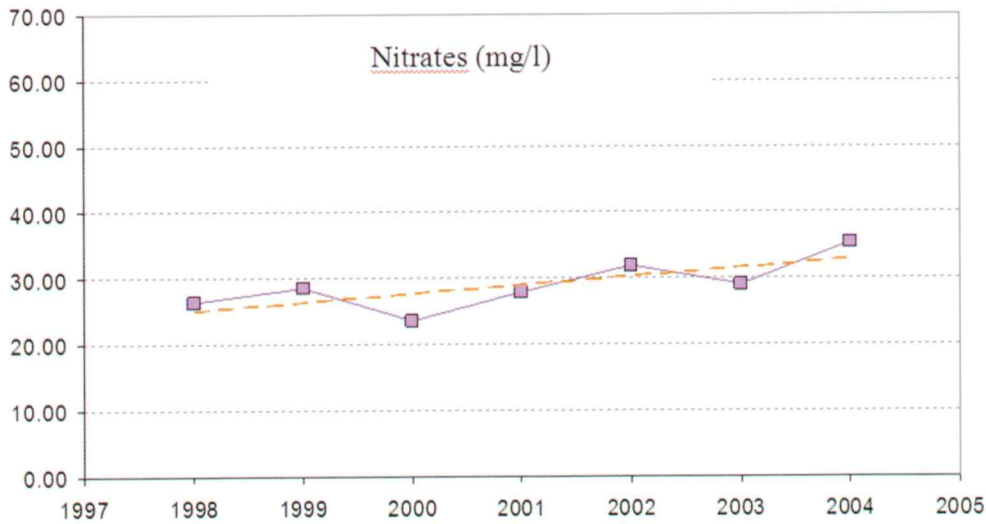


Figure 2. Upward trend of nitrates content 1999–2004 in groundwater of Krška kotlina alluvial aquifer

ing to pay additionally for restoring groundwater quality to near-background (natural) concentration and how much. The information describing these programs and presented to respondents is summarized in Table 1.

Two different levels of information were provided to two sub-samples of respondents to test the likely impact of information on respondent's willingness to pay (both yes/no and amount). A simplified set of information as compared to what

is described in Table was provided to around half of the respondents. It did not make reference to pesticides (it was assumed that people's knowledge of the presence of pesticides would influence their answer) and did not specify potential measures and economic sectors targeted by measures that would need to be implemented for reaching different groundwater quality levels.

Face-to-face interviews were performed in April/May 2006 for 429 respondents representa-

**Table 5.** Main characteristics of the two groundwater restoration programmes proposed to respondents

Main characteristics of programme(s)	Programme 1	Programme 2
<b>Expected impact on groundwater</b>	An action programme with protection measures targeting different sectors at the origin of pollution (agriculture, households, industry...) proposed for <b>stabilising nitrate and pesticide concentration</b> in groundwater	In addition to the measures proposed in Programme 1, stricter restrictions on land planning, bans of polluting products, compulsory treatment of wastewater ... imposed to <b>further reduce pollution</b> to the aquifer
<b>Potential measures and sectors targeted</b>	<ul style="list-style-type: none"> <li>• Implementation of good agricultural practices for the agriculture sector</li> <li>• Controlled used of pesticides and strict application of good practices in all sectors (agriculture, transport, gardening, etc)</li> <li>• Installation of new sewage and modernisation of existing ones for reducing leakages</li> <li>• Building of manure storage for the larger farms for better manure management</li> <li>• Improved management of septic tanks for isolated houses and installation of modern septic tanks for all new constructions/houses</li> </ul>	<ul style="list-style-type: none"> <li>• Strict land planning with ban of new activities that might potentially pollute the aquifer</li> <li>• Shift to more ecological farming for agriculture for selected sensitive areas;</li> <li>• Ban of pesticide use for gardens, transport infrastructure and municipal use;</li> <li>• Obligation for replacement &amp; proper management of septic tanks for all isolated houses</li> <li>• Shift to less polluting inputs and products for industries and households....</li> <li>• Active awareness raising campaign for the entire population</li> </ul>
<b>Overall impact</b>	This will ensure in the longer term a <b>drinking water quality for the entire aquifer</b> - additional costly treatment for drinking water will not be required. However, some <b>risk might remain for connected nature protected areas</b> and ecosystems.	Such an ambitious action programme would ensure <b>drinking water for the entire aquifer</b> and groundwater quality close to natural conditions. It would ensure <b>no risk to connected nature protected areas</b> as required for healthy development of natural ecosystems, birds, fishes...

tive of population of the Krško kotlina aquifer in terms of sex and age. Around half of the interviews took place in the street, the other half taking place at the respondents' home. Respondents from different municipalities were selected to represent different conditions in terms of distance to the aquifer. Respondents living above the aquifer, nearby the aquifer and between 5 to 40 kilometres from the aquifer were interviewed to test the assumption that their willingness to pay for restoring the quality of the Krško kotlina aquifer would decrease as one moves away from the aquifer. All data collected through interviews were then entered into a spreadsheet and analysed statistically.

### First results

Table 6 summarizes the survey results on willingness-to-pay. 63 % of respondents accepted to pay for the first scenario and among them 67 % accepted to pay for the second one, which means 42,21 % of respondents accepted to pay for both

scenarios. Respondents averaged 5,6 € per month for the first scenario with a range of 0,04 to 4,2 € per month. 50 % of them declared an amount below 4,2 €. For the second scenario, willingness to pay amount is between 0,21 and 21 €, with an average of 9,2 €. This must be added up to the first amount to obtain the total willingness amount which comes to 7,3 € for half of respondents who agreed to pay for both scenarios.

Among respondents refusing to pay 37 % refused, because it is not acceptable for them to pay as principle or because it is not their rule to pay for it: "taxes are already high enough", "polluters or the state should pay", ... Such respondents are not "true" zero bidders. They refuse to pay as a sign of protest, even if they accord a positive value to the aquifer, conducting to censored data.

Three quarters of respondents declared they had already heard about the situation of groundwater and most of them think it corresponds to reality. 83% think the first program is feasible but only just the half is confident with the results of the second scenario.

**Table 6.** Survey results on willingness-to-pay

	% saying yes.	Mean (std dev)	Median	
			Min	Max
Would you accept to contribute financially for the 1 <sup>st</sup> scenario?	63			
WTP amount for the 1 <sup>st</sup> scenario		1345 (1101)	1000	5000
Would you accept to contribute financially for the 2 <sup>nd</sup> scenario?	67 (42.21% of all)			
WTP amount for the 2 <sup>nd</sup> scenario		1147 (1000)	1000	5000
WTP amount for both scenarios		2194 (1888)	1750	9000

### Regressions

Since many respondents refused to pay, data include zero and positive values. Ordinary least squares (ols) method applied to such data would lead to a bias in the results (Greene, 2000). Ols must then be applied to the positive value only and the will to pay can be explained thanks to a logistic regression. If both zero and positive values, the bid function can also be modeled using maximum likelihood and since the responses are censored at zero (negative WTP amounts are not permitted), Tobit analysis is appropriate. Indeed it involves truncation of the dependant variable below zero. Protest answers, coming from re-



the chi-square test rejected such a hypothesis. Concerning the variable “well” and the variable “drink tap water”, the chi-square test can not be implemented<sup>7</sup>. We will make the hypothesis that the two variables are independent. Such a hypothesis is justified because only one respondent having a well drink its water. In addition to that, most of respondents never drinking tap water do so because they do not trust tap water and not because they prefer drink water from another source.

For the regressions on willingness-to-pay amount, explanatory variables, when quantitative, and elicited amounts are logged. It permits to interpret coefficients in term of elasticities. Since the Tobit model is estimated thanks to maximum likelihood, coefficients can not be interpreted. It is for this reason, that marginal effects are reported. They are calculated at the mean of the explanatory variables.

### First scenario

The parameter age is negative and statistically different from zero in logistic and Tobit equations. The older respondents are, the lower the probability they pay and the lower the amount they declare (including zeros). But once respondents decided to pay, age has no influence on amount.

Low income is significant at least at the 5% level and has a negative sign, in all models. Households with an income below 835 € would be less willing to pay for the aquifer, which is in the nature of things.

Living on the top of the aquifer has positive coefficient that is significantly different from zero. Among respondents willing to pay (ols), living above the aquifer, increases by 18% willingness to pay. This indicates that such respondents attach a higher value to the aquifer, which is partly due to the use value which is higher for them. Living at more than 5 km of the aquifer even has a more important impact on wtp, since it makes people pay 48% less and is significant at the 1% level instead of 10%.

Low income and living above the aquifer are the two variables, which appear in regression on decision to pay (logistic) and regression on willingness-to-pay amounts -for positive bidders (ols) and for all respondents (Tobit). Their sign and significance are robust across models.

Among respondents willing to pay (ols), bill elasticity is 0.33, which means if bill amount increase by 10%, then wtp will increase by 3.3%.

Respondents never drinking tap water have a higher willingness to pay than others. Such respondents may be more sensitive to water quality and most of them do not trust tap water. If water quality were perfect, with nitrates concentration as close as possible from natural state, they would probably drink tap water again.

Well is a significant variable for the decision to pay. Even if most of them (86.25%) do not drink its water, around two-third use its water and are

thus in contact with it. It increases direct use value for those who use it and option use value for the others.

Citing environment as one of the main problems in the region makes respondents more ready to pay. This answer is quite subjective. Since the subject of the questionnaire is related to environment, respondents may bias their answer towards environment, because they think it is the “right answer” to the question. This variable is also significantly positive in the Tobit model.

Being active in an environmental organization is also significant in the Tobit model as well as in the regression on positive amounts but not in the logistic. This difference confirms that there is gap between being effectively active in the field of environment and just saying environment is an important problem. Among respondent accepting to pay, involvement increases willingness-to-pay amount by 26%.

Accepting to pay because of the existence value of the aquifer provide higher values. Indeed such non-use considerations come from people having a real interest toward environment protection, not only for financial reasons but because they consider natural places do not have to be depleted by humans.

Confidence in results of the program has a strong relation with the will to pay. It is very important because many respondents do not think the results are achievable, either because politician or the society do not have the will to achieve such an ambitious program, or because they think it is not technically possible.

Coefficients are much more important in the Tobit regression. It is due to the inclusion of zeros in the regression. But the proportion remains the same, since, for example, it is still the drinking of tap water which is the variable with the higher coefficient, like in the ols regression.

### Second scenario

Once the decision has been made to pay for ensuring a drinking water quality, the only variable which explains will to pay to ensure no risk to connected protected areas is income. Respondents having a low income who accepted to pay for first scenario are more reluctant to pay for the second one than the other.

Concerning elicited amount, significant variables are the same than for first scenario, except being involvement in an environmental organization and living above the aquifer which does no more explain contribution.

Coefficients are nearly the same, except for the variable “live far from the aquifer”. It diminishes contribution of 35% instead of 48%. Since second scenario does not deal with drinking standards but with environmental issues, respondents living at more than 5 km of the aquifer are more concerned than for the first scenario, which explains a lower negative coefficient. In the same way, the ecological purpose of the second set of measures

explains that living above the aquifer is no more significant.

### Testing key assumptions and hypothesis

#### Way the interview is conducted and level of information

Type of interview (home or street), the interviewer and level of information potentially biases answers.

Home and street interviews do influence neither probability of paying nor the amount declared, if the respondent accepts. Indeed, the overall time spent for doing interviews are quite equal and thus might eliminate possible differences resulting from different interview places.

All interviewers do not obtain the same results. With some interviewers, probability to accept to pay is higher as well as willingness to pay amount. Even if information about current situation, water quality problems and improvement's scenarios were printed on the questionnaires, each one has his own way to explain and present it. It also explains that level of information does not explain answers of respondents. Interviewers can not be stuck to what they should say; there is a dialogue with respondents who often ask complementary information. In addition to that the information does not directly from the description of situation to the answer. There are biases, such as, the way respondents understand the information they get and the way they adapt their opinion to questions which are "closed".

#### Comprehension of the nature of the good

Contingent valuation is a direct valuation method, since it creates a fictive market to ask directly to respondents the value they accord to an environmental good. Nevertheless, before declaring such an amount, respondents need to clearly understand which good is at stake. Groundwater being, by definition, invisible most of the time, it is very hard to value for many respondents. A key question of the study is to assess to which extent respondents understand what they are valuing.

For people living far from the aquifer, there is independency between use of groundwater and willingness to pay, on one side, and contribution amount, on the other side. This means that respondents considered as a whole understand that the aquifer is quite far away and that its quality has no influence on the water they use. Nevertheless, 38% of respondents living at more than 5 km from the aquifer declare they want to pay in order to avoid future treatment costs. This answer is meaningless because their water supply does not come from the aquifer and will never come from it. In addition to that, it is unlikely they move above the aquifer because the biggest towns are in the circle around it.

For respondents living above the aquifer, those who use groundwater are not more ready to pay

than the other. But users declare higher amounts, which mean they are able to make a relation between improvement of the aquifer quality and the water they drink.

As a conclusion, it is not obvious that respondents understand perfectly which good they value. At least, some of them are not able to establish a right link between the aquifer and the water they use.

### Discussion and conclusions

The results obtained from the contingent valuation survey undertaken for the Kr           aquifer (East of Slovenia) illustrates people's willingness to pay for groundwater improvements. Overall, around 63% of the sample is willing to pay an average of 6,6    per household per month for ensuring groundwater remains drinkable in the longer term. Only 40% of the sample, however, is willing to pay for bringing groundwater back to close-to-natural concentrations of nitrates with an additional 4,8    per household per month. These amounts represent 15–20% of households' average monthly water bill.

Significant differences in willingness-to-pay values exist between respondents. Living on top of the aquifer, the trust in the program of measures proposed for improving groundwater quality, being member of an environmental organization or putting the preservation of the patrimony as priority justification for groundwater quality restoration positively influence willingness-to-pay values. Also, a higher percentage of respondents with high incomes are ready to contribute to both groundwater improvement programs as compared to the low income group. Furthermore, low income groups will contribute with smaller values. No difference in people's willingness to pay for groundwater improvements was found between the two sub-sample that received different information on the current situation and possible groundwater improvement measures. This might be related to the difficulty for respondents to grasp groundwater issues and to understand rightly the good (changes in groundwater quality) they are asked to value.

Overall, results are coherent with basic assumptions and theory. And they are in line with results obtained from other contingent valuation studies – apart for sex-related differences commonly found in other studies (men being willing to pay more than women) but not valid for the Kr           aquifer. The relatively low overall statistical significance of the regressions obtained is also similar to what is commonly found in other studies – stressing that only part of the variability of respondents' responses can be explained with the information obtained and variables considered.

As indicated in the literature, contingent valuation might not be the best approach to value groundwater quality (because of the difficulty for respondent to understand the good they need to value and that is not visible). However, it re-

mains the only option available for capturing non-use values. The values obtained with this survey could be used for first assessments of benefits from groundwater quality improvements in other Slovenian aquifers *at risk* or *potentially at risk*, leaving additional surveys or methods for obtaining new site-specific values to areas where groundwater improvement is politically sensitive and/or costs and benefits of the same order of magnitude.

The test demonstrates that such contingent valuation surveys can be implemented under Slovenian conditions (protest answers, for example, remain within acceptable limits). Simplification of the questionnaire would be possible if the objective is to estimate total willingness-to-pay values only – as opposed to identifying the relative dependency between willingness-to-pay and different characteristics of respondents. Further testing of valuation methods (contingent valuation, but also hedonic pricing and transport cost methods) would be required for estimating additional values of environmental costs for Slovenia – in particular for other types of waters (surface water, coastal water). In addition to providing estimate of values of environmental costs/benefits, such contingent valuation surveys would contribute to raising people's awareness on water protection and on significant water management issues faced in Slovenia.

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<sup>1</sup> The Krka Pilot project or the *Technical Assistance for the preparation of the Krka river basin management plan located in the Krka sub-basin* is co-financed by the European Union (PHARE funding). It aims at testing methods and tools for supporting the implementation of the new Water Law/EU WFD and the development of river basin management plans in Slovenia. It has been implemented by a consortium led by Hidroinženiring d.o.o. (Slovenia), with ECORYS Nederland (The Netherlands) and IEI d.o.o. (Slovenia) as members of the consortium.

<sup>2</sup> "Stratégie d'échantillonnage et modèles de comptage dans la méthode des coûts de transport." Sébastien Terra, MEDD.

<sup>3</sup> "The value of trees, water and open space as reflected by house prices in the Netherlands", Luttik.

<sup>4</sup> (Estimated value – actual transaction price)\*100/estimated price

<sup>5</sup> Pre-testing was performed for two consecutive days beginning of April 2006. Around 50 respondents from the Ljubljana and Krško kotlina areas were interviewed with changes and improvements made to the original questionnaires to account to respondent's first responses and reactions. Pre-testing was also instrumental in training interviewers in the use of the questionnaire.

<sup>6</sup> Total wtp = wtp for first scenario + wtp for second scenario if both are different of zero. Indeed second wtp is expressed on top of the first one.

<sup>7</sup> Chi-square test can not be implemented when one box of the contingent table contains less than 5% of the sample.