Reference Information Specifications for Europe (RISE)
Specific Support Activity SSA3-2005-012141
Project co-funded by the European Commission within the 6th Framework Programme (2002-2006)
Integrating and Strengthening the European Research Area – Priority 4: Aeronautics & Space

Cost Benefit Report
Version 1.1

Deliverable number: 30 [3.3.1]

Date: 13 November 2007

Project started: 1st September 2005
Duration: 27 months

Project Coordinator: Nick Land/Dave Lovell, EuroGeographics

Bundesamt für
Kartographie und Geodäsie

Customer:	European Commission
Customer Reference:	Contract FP6-012141
Project Title:	RISE: Reference Information Specifications for Europe
Document Title	Cost Benefit Analysis
Principle Author	Martin Klopfer
Principle Contributors	Jörgen Hartnor, Ulf Lundquist, Christine Brönner, Cecile Herviaux, Sabine Afflerbach, Helen Eriksson
Responsible Partner	OGC-E
Reviewed By	RISE PCMG
Approved by	Dave Lovell
Filename	RISE30 Cost Benefit Report V1.1
Distribution	PU

Contact	http;//www.eu-rise.org/
	mklopfer@opengeospatial.org

Revision History			
Version	Author	Date	Comments
V 0.5,0.6,0.7	M. Klopfer	March 07	Merged draft text into document template; Full revision based on PCMG Discussion; Added BRGM Cost benefit information.
V 0.8	C. Broenner	30 May 07	Full Revision and Additional comments
V 0.9, 0.91	M. Klopfer	July 07	Minor updates; Updates according to HAC PB discussion and inclusion of internal efforts
V 0.92	Jörgen Hartnor	17 Sep 07	Full Revision
V 0.93	M. Klopfer	25 Sep	Accommodation of comments & edits
V 0.94	W. Cudlip	27 Sep 07	Inserted info on RTE and updated format.
V 1.0	M. Klopfer	28 Sep 07	Final Proof
V 1.1	M. Klopfer	13 Nov 07	Accommodation of second Review Comments

This document has been prepared for use by the RISE Project Partners. It can be used or disseminated consistent with the document classification given on the front page (see coding below).	
PU	Public
PP	Restricted to other programme participants (including the Commission Services)
RE	Restricted to a group specified by the consortium (including the Commission Services)
CO	Confidential, only for members of the consortium (including the Commission Services)

Executive Summary

The key objective of the RISE project is to develop methodologies and guidelines for the development of harmonised data product specifications. To aid exploitation activities and support the uptake of the RISE methodology, Work Package 3.3 addresses the costs of developing harmonised data product specifications and outlines the foreseen benefits of applying the RISE methodology.

The documentation of cost aspects identified and actual costs incurred within RISE for the development of selected harmonised data product specifications and the implementation of test Data Products helps to understand and quantify costs and benefits for data harmonisation work during the implementation of the INSPIRE Framework and later phases of GMES operation.

The actual benefits cannot be quantified on a generic level, but need to be addressed on an individual basis, taking into account the specifics of the domain and players involved. Besides the description of the potential generic benefits resulting from each of the steps in the RISE approach, the expected benefits of data harmonisation in general are outlined in for various identified stakeholders of the geospatial community in Europe and international standardisation organisations.

RISE provides with this document a process outlining the benefits of each of the steps of the RISE methodology on a qualitative level and identifies the areas which need to be considered in detail for a quantitative case by case study. By outlining the necessary steps and related efforts, each third party will be able to do a cost estimate based on its very own internal structure, processes and procedures as well as financial framework. In the same way the benefits are outlined on a generic level, thus allowing an organisation to calculate e.g. potential savings on the production side or gains due to newly addressable market segments based on their very own cost structures and marketing strategies.

Even though the RISE approach could not be validated with a detailed Cost Benefit Analysis (CBA) based on detailed financial figures (as these are not available), examples from RISE Use Case participants confirmed the validity of the approach. A crucial aspect for a credible CBA is the availability of reliable and comparable figures for scenarios, both before and after the introduction of harmonisation efforts.

It is therefore hoped, that the RISE Methodology will be taken up and supported by further research towards more detailed cost/benefit analysis.

This document thus offers an acceptable model for cost benefit estimates associated with the future roll out of harmonised data products and other (to be developed) specifications.

Terms and Abbreviations

AEAG	Agence de l'Eau Adour-Garonne
AELB	Agence de l'Eau Loire Bretagne
AERMC	Agence de l'Eau Rhône Méditerranée et Corse
AESN	Agence de l'Eau Seine Normandie
BSS	Banque du Sous Sol
CBA	Cost Benefit Analysis
DEM	Digital Elevation Model
DIREN	Direction Regionale de l'Environnement
DRIRE	Directions Régionales de l'Industrie de la Recherche et de l'Environnement
DRAF	Direction Régionale de l'Agriculture et de la Forêt
DRASTIC	Software for Aquifer Modelling (Aller et al., 1987)
EU	European Union
FP	Framework Programme (of the European Commission)
GIS	Geographic Information System
GMES	Global Monitoring for Environment and Security
GML	Geography Markup Language
GRAPPE	Laboratoire GRAPPE, Ecole Supérieure d'Agriculture d'Angers
HUMBOLDT	A GMES project to support the harmonisation of geospatial data in INSPIRE
IDPR	Indice de Développement et de Persistence des Réseaux
IGN	Institut Géographique National
INSPIRE	Infrastructure for Spatial Information in Europe
JRC	Joint Research Center of the European Union at Ispra/Italy
MEDD	Ministère de l'Ecologie et du Développement Durable
MISE	Mission Inter Services de l'Eau
MNT	Modèle Numérique de Terrain
MOTIIVE	Marine Overlays on Topography for Annex II Valuation and Exploitation
NLS	Swedish National Land Survey
NPdC	Nord Pas de Calais
OGC	Open Geospatial Consortium
PNR	Parc Naturel Regional
RBD	River Basin District
RBMP	River Basin Management Plan
RoI	Return on Investment
SDI	Spatial Data Infrastructure
SRTM	Shuttle Radar Topography Mission
SSWS	Swedish Surface Water Standard
Statens Kartverk	Norwegian Mapping Agency
SUGAR	Surface water / groundwater contribution index
UML	Unified Modelling Language
WFD	Water Framework Directive

References

The following referenced documents are indispensable for the application of this document.

[1] RISE Deliverable 15 V1.2. – Methodologies & Guidelines on Use Case and Schema Development.
[2] RISE Deliverable 18 V1.5. – Use Case Document: Diffuse nutrient leakage reporting to the Water Framework Directive.
[3] RISE Deliverable 25 – Data Product Specification. V1.0.
[4] RISE Deliverable 17 – System Architecture Outline. V1.0.
[5] RISE Deliverable 36 - Final Report on Testing System. V1.0.
[6] Craglia, M. (2003). Contribution to the extended impact assessment of INSPIRE, Environment Agency for England and Wales / Sheffield University.
[7] Halsing, D., K. Theissen, *et al.* (2004). A Cost-Benefit Analysis of The National Map, USGS: 40.
[8] EC (2006). Assessing the impacts of Spatial Data Infrastructures. Report of International Workshop on Spatial Data Infrastructures' Cost-Benefit / Return on Investment, Ispra, Italy.
[9] Mardhel, V., A. Gravier, *et al.* (2006). Cartographie de la vulnérabilité simplifiée des eaux souterraines du bassin Seine-Normandie. Application aux sites BASOL. International Symposium - Aquifers Systems Management, Dijon, France.
[10] Dufourmont, H. (2004). Extended Impact Assessment of INSPIRE based on revised scope, ESTAT.
[11] Boyd, J. (1998). The Benefits of Improved Environmental Accounting: An Economic Framework to Identify Priorities. Discussion Paper 98-49. Washington, Resources for the Future: 26.
[12] Graveline, N., H. Lüegke, *et al.* (2006). Synthesis report on the impact assessment of ETs on decision making and the development of river management plans including distributional effects.
[13] UNECE (2000). Guidelines on Monitoring and Assessment of Transboundary Groundwaters, UN/ECE Task Force on Monitoring & Assessment under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992): 64.
[14] Macauley, M. K. (2006). "The value of information: Measuring the contribution of space-derived earth science data to resource management." 22(4): 274-282.
[15] Gravier, A., J.-Y. Koch-Mathian, *et al.* (2006). Croisement des données des sites BASOL avec la vulnérabilité simplifiée des nappes du bassin Seine-Normandie. Rapport de synthèse., BRGM: 95.
[16] ShapeChange – a UML to GML Application Schema Convertor Tool. http://www.interactive-instruments.de/ugas/
[17] UMN MapServer. http://**mapserver**.gis.umn.edu/
[18] SS 63 70 08 EN:2006 – "Geographic information – Surface water systems – Concept and application schema"

RISE documents are available from:
http://www.eu-rise.org/ or http://www.eurogeographics.org/eng/03_RISE_downloads.asp

Table of Contents

1. Scope

The key results of the RISE project are methodologies and guidelines for the development of harmonised data product specifications. To aid exploitation activities and support the uptake of the RISE methodology, this document addresses the costs of developing and implementing harmonised data product specifications and outlines the foreseen benefits of applying the RISE methodology.

The documentation of cost aspects identified and actual costs incurred within RISE for the development of selected harmonised data product specifications and the implementation of test Data Products helps to understand and quantify costs and benefits for data harmonisation work during the implementation of the INSPIRE Framework and later phases of GMES operation. The cost factors recognized are outlined for each relevant step of the RISE methodology and documented in a process which shall aid users to sketch the costs and benefits for the development of harmonised data product specifications for their specific applications. The actual benefits cannot be quantified on a generic level, but need to be addressed on an individual basis, taking into account the specifics of the domain and players involved. However, RISE provides an outline of the benefits of each of the steps of the RISE methodology on a qualitative level and identifies the areas which need to be considered in detail for a quantitative case by case study. This document thus offers a sustainable and acceptable model for future roll out of these and other (to be developed) specifications.

The RISE approach should ideally be validated by actual users of selected application scenarios and include a detailed breakdown of production process costs for an existing product, as well as the development and implementation costs for the creation and distribution of harmonised data products, and the costs of the resulting production process. It is suggested to initially validate these cost and benefit factors in a test environment for the Use cases described. The Test environment would help to illustrate the applicability of the process for implementation of the RISE methodology towards more efficient processing and cost reduction in data product harmonisation. Within the test environment that was set up in RISE, this validation could unfortunately not be carried out to the full extent, partly due to time and resource constraints for the implementation, partly because detailed costs could not be obtained for existing processes that were documented in the RISE Use Case Description.

However, to provide an idea about relevant Cost and Benefit factors identified by the RISE approach and to validate some of the underlying assumptions, this document contains two examples of Cost Benefit Analysis (CBA), which have been carried out by partners of the RISE consortium on activities. Although they are not directly following the complete RISE Methodologies and Guidelines, they are closely related:

- The first example is presented by the National Land Survey of Sweden – Lantmäteriet – (NLS). Their CBA is looking at the development and implementation of the Swedish Surface Water Standard for the hydrography data.
- The second CBA example (detailed in the Appendix) has been developed by BRGM for the introduction of the IDPR Methodology. The elevation data input processing for that index calculation has been described in the RISE Use Case document. It provides, on an abstract level, an outline of relevant costs and benefits parameters associated with the large scale implementation of a methodology and can therefore be used to calculate actual values for putting into practice methodologies like the RISE one.

2. RISE Approach to CBA

Cost Benefit Analysis (CBA) is an extensive field of work, with probably as many different views on approaches, metrics and conclusions as there are studies. When RISE was proposed and its final objectives and scope negotiated with the Commission, the Cost Benefit Analysis as part of WP3 was suggested to be aligned with the MOTIIVE activities in this area and to follow the MOTIIVE methodologies to leverage on any potential synergies.

Whilst the RISE methodology has been considered by MOTIIVE, the initial idea of applying the MOTIIVE results 1:1 to the RISE use cases had to be dropped. The main reason being, that finalised input from MOTIIVE was not available in time to pursue the CBA work in RISE within the timeframe of the project. As a result, RISE has developed its own CBA process approach, which can be applied to any specific use case for data harmonisation. This also turned out to be more in line with the key objectives of providing a repeatable methodology.

After careful review of the particulars of the chosen RISE Use Cases and available information that could be processed to meet the objectives of the CBA in RISE, namely to aid exploitation activities and support the uptake of the RISE methodology, the Management Board of RISE unanimously agreed to re-align the initial activity and follow an approach, to which it would be better suited:

To achieve credible results, the traditional approach to a cost benefit analysis would have involved a full documentation of costs associated with the chosen use cases, and, more importantly, would have required the implementation of a parallel use case based on the proposed harmonised data products for an in depths identification of benefits in a quantitative way. However, such activities are outside the scope of RISE due to the limited resources and time available and hoped to be dealt with in future work.

The alternative path chosen and outlined in this document therefore provides a template that can be used by potential stakeholders, such as other projects like HUMBOLDT, Data Providers or any other third parties to gain a first understanding of the Cost-Benefit issues associated with the creation of harmonised data products. Since the described process outlines the major steps required and provides an indication of the effort related to each step, this will allow an interested party to fill in details according to its own cost and resource framework and to make a reasonably informed decision in due course. It also sheds some light on the relevant parameters and factors to deploy the RISE Methodology and to develop a more specific and detailed cost benefit analysis as part of any project planning and implementation.

The approach to determine the cost and benefit parameters associated with the use of the RISE methodology for the development of harmonised data products is outlined below. The publicly available documents of the International Workshop on SDI Cost-Benefit and Return on Investment held in Ispra, Italy, in January 2006 provide an excellent overview for the understanding of these methodology steps. The material greatly enhanced the comprehension of potential factors, especially when it comes to understanding and judging benefits for the development of harmonised data products and for deploying the RISE methodology.

2.1. International Workshop on SDI Cost-Benefit & RoI

The International Workshop on SDI Cost-Benefit and Return on Investment (RoI) took place on the 12th – 13th January 2006 in Ispra, organised by the Joint Research Centre in partnership with the US Federal Geographic Data Committee, GeoConnections Canada, and the Geoide Network. The key findings, as well as all presentation and reference material, are available at the JRC website at: http://www.ec-gis.org/sdi//ws/costbenefit2006/index.cfm.

Whilst the workshop materials provide a good insight into CBA activities carried out as part of the implementation of spatial data infrastructures (SDI) and e-government programmes, they also highlight the complexity and multi-scale facet of the CBA issue as well as the general challenge of pinpointing benefits at a quantitative level. Detailed impact assessments and post-project experiences, if analysed, are rarely published. This may to a degree be related to the topic that documenting the benefits and impact on internal business processes and procedures also provides third parties with potentially sensitive business information.

RISE has made the experience that in direct interviews with practitioner users, people were quite willing to support the project with information on their processes and procedures as input to the Use Case Analysis – on actual cost issues however, be it for existing processes, the potential for efficiency improvement or potential new markets, it had to be realised that actual figures are typically not assembled and/or communicated. In due course this prevents third parties such as RISE to carry out any credible in depths studies, unless these are directly commissioned by stakeholders themselves, with full access to all relevant CBA parameters and aspects.

The reviewed material inspired especially the definition of three types of benefits, which need to be identified as part of the RISE activities [1], i.e.:

- *Efficiency Benefits*
  Often called "costs savings" or "costs-avoided" benefits, efficiency benefits are those that arise by reducing the costs to perform existing tasks in an organisation. This is most often achieved by making it faster and cheaper to carry out tasks and projects. Efficiency benefits may be directly measured in terms of the number of staff hours/ salary that are saved ([6], [7], [8]).

- *Effectiveness benefits*
  Sometimes called "value-added" benefits, effectiveness benefits are those that arise by improving the outcome of projects or tasks because of better information (e.g. reduced uncertainty due to higher quality or more up-to-date data) or the addition of new tasks that could not be performed before ([6], [7]).

- *Social-political benefits, including:*

  - Benefits to citizens (for example greater access to information, more transparent and accountable governance, greater empowerment and participation)
  - Benefits to government (for example improved collaboration with other stakeholders within and outside government, greater political legitimacy)
    Benefits to business (for example increased innovation and knowledge spill over, increased concentration of and quality research, new business opportunities and applications, job creation).

.

2.2. The RISE Approach

The RISE methodology for the CBA is mainly based on a review of the methodologies and key findings from the JRC Workshop and on the spiral approach of the RISE methodology The main difference from traditional CBA approaches is that RISE has based its CBA work on the documentation of the costs which have been incurred in the steps of the methodology for the development of harmonised data product specifications and outlines the efforts related to the implementation of the identified services in the test environment. By presenting this approach as a defined process, each stakeholder with an interest to develop harmonised data products can use the RISE Methodology and establish the specific costs by applying its rates to the outlined efforts. RISE qualifies the benefits and provides arguments why applying the methodology as a whole has a potential for improved processes and reduced overall costs.

As outlined in the Use Case Description document, RISE covers the input data processing from its source to the point where the pre-processed data sets are handed over for actual modelling, and does not include a final product as delivered to the Commission.

This phase of the data processing includes primarily data providers and integrators as key stakeholders. For the purpose of identifying actual effort estimates for the development of a harmonised data product, RISE has documented the effort spent on the development of harmonised data product specifications. This process follows the steps described in the RISE 'Methodologies & Guidelines on Use case and Schema Development'.

- Development of use cases based on a use case template and the checklist provided in RISE Deliverable 4.1.1 'Methodologies & Guidelines on Use case and Schema Development' [1]

- Identification of the key harmonisation requirements that need to be supported by the Data Product Specification

- Development of the Data Specification following ISO 19131 (Data Product Specification)

- Implementation of the Data Specification, testing based on the use case(s) and validation of the solution

- Maintaining a consolidated feature data dictionary and a common glossary of terms based on all GMES/INSPIRE data specifications to ensure consistent use of terminology

For each of the steps in the workflow of creating harmonised data products, the RISE CBA outlines the scope, required efforts and anticipated benefits.

The final step and validation for this Cost Benefit Analysis approach would be to apply it to real world scenarios with full access to all relevant CBA parameters. Since due to limited access to actual financial information of stakeholders this was not possible within the scope of RISE, the project tried at least to validate the approach with some of the involved users. The key objectives were to verify if the process is practicable, to provide an understanding of the cost factors involved in data harmonisation and validate if the qualified benefits of harmonised data delivery are sufficiently supportive to initiate the development of harmonised data product specifications and data products.

By following this pathway, RISE intends to support the suggested route forward as outlined in the key findings of The International Workshop on SDI Cost-Benefit and Return on Investment:

> *One possible route to make progress is to conduct studies of SDIs at the regional (sub-national) level focused on specific thematic areas and applications. This could have several advantages: firstly, the sub-national (or small nation) focus could make it easier to identify stakeholders and user communities; secondly, the thematic and application-driven focus could allow a clearer identification of benefits as expressed by user groups; thirdly, it might be possible to test hypotheses on the contribution of SDIs to regional economic development and innovation by comparing similar regions, initially in the same country, and then across countries with and without SDIs.[1].*

3. Applying the RISE CBA on RISE Harmonisation Examples

The key aspect of the RISE Methodology is to utilise a Use Case Analysis to identify specific data harmonisations requirements, e.g. common terminology, co-ordinate reference systems etc. This will be derived from the general user requirements which an application poses, such as the need for a harmonised WFD reporting for surface water bodies. The Use Case analysis provides the necessary understanding of relevant data sources and models, actors and their interactions, and the workflows towards meeting the user requirements posed by an application. The process involves an 'as-is' analysis followed by a gap analysis and a definition of a harmonisation approach. These combined activities assist the definition of a harmonised Data Product Specification and the subsequent development of harmonised data products.

This section reviews the steps taken to develop harmonised Data Product Specifications for three selected themes based on the RISE Methodology and describes the related efforts as well as expected benefits from following this Methodology.

3.1. Use Case Documentation

3.1.1. Scope

The RISE Methodology provides a Use Case Template and a Checklist Spreadsheet addressing specifically the data harmonisation components laid out by the RISE Methodology and Guidelines to help with the analysis process.

The Use Cases developed in RISE provide a working example on the use of RISE Methodology and Guidelines on the themes of hydrography, land cover and elevation. These components are relevant to Diffuse Nutrient Leakage reporting and are also relevant to the INSPIRE 'priority common basic data' list and to many GMES applications. The RISE Methodology follows an iterative approach, where the results of one cycle help to refine the identified user requirements as input to the next iteration. The RISE Use Case Document documents the approach and results for the initial cycle and contains a number of pointers to activities which would need to be done in the following iteration.

3.1.2. Efforts

WFD Reporting had to be carried out by all EU Member States for the first time in 2005 under a limited set of requirements and guidelines for the next reporting in 2010 are under revision. Unfortunately exactly this situation of being between two reporting periods which are neither identical, nor are the future requirements fully specified, has caused a significant overhead in the development of the Use Cases and the closing of information gaps.

The RISE methodology assumes that there is a clear user-driven overall harmonisation requirement and that the application-specific harmonisation requirements can be determined during the Use Case Analysis. In practise, however, particularly at this stage of the development of the WFD reporting requirements, the overall harmonisation requirements are not too well defined, nor are they actually driven by the users who have been contacted. As a consequence RISE had to make some assumptions following the reiterative approach of the RISE Methodology when a clear requirement was not defined. Also, the data sources employed for the analyses in the various countries are often not well documented in terms of the data harmonisation components and this expertise is not always readily available.

These two factors highlight that the development of specifications for harmonised data products will be a challenging task in the foreseeable future, unless it is taken up by key stakeholders.

The total effort exerted on the development of the use cases in RISE amounted to 4.5 Person Months which included the background search on the chosen topics, selection of users and scenarios, physical meetings with users to gather information on their processes and procedures and follow up activities by phone and e-mail.

It is anticipated that the total effort required for the documentation of user requirements on additional topics can be significantly reduced, if the process is initiated by stakeholders, who have ready access to internal process information and a direct means to motivate user engagement, so that they are not only relying on voluntary participation. Well documented processes, materials and interactions are essential to pursue this activity in an efficient manner.

Based on the experiences made within RISE, the total investment required to apply this process to additional themes is estimated to be likely in the region of 1-2 person months per theme.

3.1.3. Benefits

It is accepted best practise to start with a documentation of the user requirements before embarking on any IT project and there are many ways and options to do so. The main objective is always to outline the framework against which a solution is to be developed and to provide some metrics, against which progress and impact can be evaluated. By following the RISE Methodology and the Use Case Templates, the key benefit lies in the application of a standardised approach based on ISO and OGC standards, which helps to create comparable and in the end interchangeable results.

3.2. Data Specification Development

3.2.1. Scope

The Key Harmonisation Requirements are derived from Use Case Documentation and as far as they relate to input data are transformed to a first-cut of data product specifications, according to ISO 19131 Data Product Specification, but not fully documented at this early stage.

If a data product specification for the relevant input data already exists, an initial analysis will be carried out to determine if the existing specification should be amended or if the requirements are different enough to warrant the creation of a separate data product specification.

A vital part of a data product specification is the ISO 19109 application schema specified in UML. A UML application schema is a conceptual schema for data required by one or more applications, modelled in UML. This application schema describes the conceptual model for the data that is supposed to fulfil the identified requirements.

A GML application schema can be derived automatically from the UML application schema, applying the rules defined in ISO 19136 GML Annex E, through the use of appropriate software tools. Such tools are being developed by members of the OGC [16] and related on-line services are under development [16]... The GML application schema provides a syntax for a concrete representation of data according to the data product specification.

3.2.2. Efforts

The overall effort to derive the harmonisation requirements form the use case specification and to develop the conceptual schema as well as the harmonised data product specification amounted to a total of 13 Person Months of effort for the three chosen topics.

The average effort to develop a harmonised data specification according to the RISE Methodology would be in the range of 3-4 Person Months for a given theme. It should be considered though that due to a lack of initial input, RISE had to address some use case specification gaps in this activity, which may not apply when the activity is driven by key stakeholders, including the users. At the same time the development of harmonised data sets for a large scale deployment would require the involvement of a representative user base, whose management creates a certain overhead to be taken into account.

3.2.3. Benefits

At a first glance, the immediate benefits are of social and political nature, since the main driver for harmonisation are common European policies and directives, with an overall objective to improve access to information and data.

However, this also provides effectiveness benefits through improved availability of data for the data integrator, presenter and viewer, which should act as incentive to participate in this phase and ensure that requirements are adequately interpreted and reflected in the product specifications.

For data providers the harmonised data specification development provides the chance to receive valuable input to their mid- and long-term strategies and to align internal processes for emerging markets. Since data providers should have an interest to market their products to as many segments as possible with least effort, their participation in this step can help to maintain flexibility of the resulting products to serve multiple domains efficiently.

3.3. Data Specification Implementation & Testing

3.3.1. Scope

The RISE Methodology recommends the testing of a new harmonised Data Products Specification with a real implementation within a Test Environment. This is particularly important in the RISE context because a key objective of RISE is to show how, in principle, new Data Products can be created on-the-fly without changing the underlying database. If on-the-fly creation is required in a new application then it would be particularly beneficial to verify that this was possible in a real implementation.

3.3.2. Efforts

It is possible to use Commercial-of-the-Shelf (COTS) software tools to build a Test Environment. Very little actual software programming is required, although configuring and integrating the available software tools does require a certain level of expertise and can take significant effort.

The principle software components of the RISE Test Environment were an Oracle database and the Snowflake Go Publisher software for automatic Schema translation. An Oracle database implementation can be relatively expensive both in terms of software licence (many 1000's euros) and the technical staff required to maintain its operation. However, in many cases implementers may already have access to Oracle database facilities and the incremental cost of using it for a Test Environment implementation may be relatively small. In some circumstances it might also be possible to employ free, open-source database software such as PostGreSQL. However, compatibility between the different software components of the system would need to be taken into account.

The Go Publisher software is available for an annual licence of about 2000 euros. However, operating this software requires a certain level of expertise which could take several weeks to acquire. Training courses and support are available from Snowflake and this would add to the overall cost. Other similar software packages are available, e.g. XtraServer from Interactive Instruments. The field is currently undergoing rapid development and so a survey of suitable software should be carried out as part of the planning for an implementation.

Other components of the RISE Test Environment (RTE) implementation made use of free, open-source software. This includes the ShapeChange UML to GML Application Schema (UGAS) Converter Tool [16] and the OGC Compliant Minnesota Web Map server [17].

Other software elements are required to implement a Test Environment, for example, to set up on-line access through standard web-pages. And of course, hardware costs would be involved if one needed to buy specific computers to host the implementation. However, processing requirements are not onerous for a test implementation and so the hardware costs could probably be limited to a few thousand euros.

In summary, one would estimate the cost of setting up a test environment as in the range of 3 to 6 months of effort plus hardware and software licence costs. This includes a reasonable amount of time for an implementer to become familiar with software technology that may be new to them. An implementation by someone who was very experienced in the technology could create a test environment in much less time than this.

Details of the RISE Test Environment can be found in the RISE Final Report on the Testing System [5].

3.3.3. Benefits

We can summarise the benefits of implementing a Test Environment as:

- It verifies that the Data Specification contains enough information to support an implementation.
- It allows verification of the type and nature of the input data required to support product generation.
- It allows users to interact with the new Data Products in order to confirm that their defined Data Product Specification is actually fit for purpose.
- It allows an efficient cyclical approach to Data Product Specifications to be employed allowing feedback from one iteration to aid in the development of an upgraded version.
- One gets better User acceptance of new Data product Specifications if one can show implementations have been tested.
- The Test Environment could be made accessible to Users to allow them to carry out their own testing if further “encouragement” was required.
- The cost of implementing the Test Environment can be used to estimate more accurately the cost of developing a full scale implementation.
- The Test Environment development provides a training environment allowing staff to gain experience before setting out on a major system implementation.

4. Stakeholder Specific Benefits

The RISE CBA approach deals with factors which incur costs and benefits when implementing the RISE Methodology for harmonised data product specification development. RISE deals with the phase of input data processing (towards a reporting item). The key stakeholders involved in that phase, though they can be one and the same, can broadly be categorized into data providers and data integrators. However, in a commercial approach to the development of harmonised data products the following groups would all potentially benefit and should be recognised in a CBA:

- Data Providers
- Data Integrators
- Harmonisation and Standardisation Initiatives
- ESA and EU FP6 / FP7 Projects
- End Users

The expected benefits for these groups are outlined in the following tables:

4.1. Data Providers

Data Providers form the foundation of each country's national data infrastructure and thus hold the key to a successful implementation of any data harmonisation efforts. Their existing data models and resulting products are geared towards existing business models and markets and the greatest benefits are to be expected in the areas of efficiency and effectiveness.

Data Provider	Description of harmonisation activities likely needed	Possible use of Methodologies and Guidelines (M & G) document	Potential benefits	Efficiency Benefit	Effective-ness Benefit	Social-Political Benefit
European National Mapping and Cadastral Agencies, European Meteorological and Hydrological Institutes, European Geological Surveys	They will have to implement the parts of the INSPIRE directive for which they are data providers.	The M & G document provides a proven and standardised method for data harmonisation that can guide them in their work. It also describes how existing datasets can be mapped to harmonised data specifications.	Enables a more straight forward and time saving approach as well as increased usage and thus more income.	√	√	
Satellite data providers and Aerial Photography companies	Most of the geographical data are provided to users by license agreements. These data would benefit from being compliant with a harmonised standard.	The M & G document provides a proven and standardised method for data harmonisation that can guide them in their work. It also describes how existing datasets can be mapped to harmonised data specifications.	Enables a more straight forward and time saving approach as well as increased usage and thus more income.	√	√	

4.2. Data Integrators

Data integrators are often faced with the situation of having to integrate and manipulate heterogeneous data from different sources in order to get the desired result. Once data is harmonised and exchanged using a predefined format, this task will either be much simplified or not necessary to perform at all any more. Again, similar to the data providers, this group can directly benefit in the areas of effectiveness and efficiency improvements. Especially when cross-administrational or cross-boundary issues need to be addressed, the availability of harmonised data products promises a significant improvement.

Data Integrator	Description of harmonisation activities likely needed	Possible use of Methodologies and Guidelines (M & G) document	Potential benefits	Efficiency Benefit	Effective-ness Benefit	Social-Political Benefit
Eurogeographics	Coordinates the implementation of different harmonised products and data (e.g. Euro Regional Map, EuroRoadS). They also have the possibility to arrange different work shops on the data harmonisation theme for their members.	Eurogeographics participates in the RISE project and is thus in a good position to understand and carry forward the RISE methodology amongst its members, on its website and in its various technical working groups. Eurogeographics can follow the M & G when creating new pan-European products and also use it as reference material on data harmonisation workshops.	Eurogeographics can, in its continued work, build on the experience that has been gained through the RISE project and thus do not need to repeat this work. Enables a more straight forward and time saving approach.	√	√	
GMES fast track services	Will contribute to facilitating access, use and harmonisation of geospatial information at pan-European level. They will develop the needed spatial data infrastructures and the implementation of the INSPIRE directive will be supported.	If the M & G document is used, it would give a standard approach to all harmonisation efforts while creating the fast track services.	Enables a more straight forward and time saving approach. Reduces the costs of implementations	√	√	

Data Integrator	Description of harmonisation activities likely needed	Possible use of Methodologies and Guidelines (M & G) document	Potential benefits	Efficiency Benefit	Effective-ness Benefit	Social-Political Benefit
Content Industry	When all EU member states are going to implement the INSPIRE directive many GIS consultants will be needed to help out with the data harmonisation.	If the M & G document is used, it would give a standardised approach to all harmonisation efforts.	Enables a more straight forward and time saving approach. Reduces the costs of implementations in Member States	√	√	
GIS vendors	Will need to see to it that their products can support the use of ISO standards that the M&G document and INSPIRE recommends to use, especially GML	Can see to it that their software makes it possible to exchange data using the standards that the M&G document recommends	The SDI initiatives (out of which INSPIRE is one) require harmonised geospatial data. When producing these data, the demand for GIS will increase. When more harmonised data is available, the usage of such data GIS products is likely to increase as a result.	√	√	
WISE	The WISE Technical Group is currently in the process of updating the WFD GIS Guidance document.	By providing a standards based template, the M&G document could support the development of common implementation strategies	A “Common Implementation Strategy” process is applied during the implementation of first WFD and now the other water-related policies			√

4.3. Harmonisation and Standardisation Initiatives

Harmonisation and standardisation initiatives play a crucial role in producing methods as well as standards and for the implementation of harmonised data products and services. The initiatives core interest is to see their recommendations and standards not only being accepted, but practically implemented in operational environments.

Harmonisation and Standardisation Initiative	Description of harmonisation activities likely needed	Possible use of Methodologies and Guidelines (M & G) document	Potential benefits	Efficiency Benefit	Effective-ness Benefit	Social-Political Benefit
INSPIRE Drafting Teams (DT) and Thematic Working Groups (TWG)	Creation of various documents (e.g. Methodology for the development of data specifications, Generic Conceptual Model) Compilation of INSPIRE Implementing Rules.	The final version of the M&G document has been submitted to DT "Data Specifications". They have adapted it to the INSPIRE context to create the INSPIRE document D2.6. The TWGs that will create the theme data specifications will use the INSPIRE methodology as guidelines	The M&G document has been tested under real world conditions. Furthermore, the experts involved in both RISE and INSPIRE have gained useful experience within RISE	√	√	
OGC	Compilation of standards to be used for data harmonisation.	OCG-Europe participates in the RISE project and OGC is thus in a good position to understand and carry forward the RISE methodology amongst its members, on its website and in its various technical working groups. In particular since most of the RISE methodology is based on OGC ORM.	OGC can, in its continued work, build on the experience that has been gained through the RISE project and thus do not need to repeat this work. RISE has tested and promotes the OGC ORM via the RISE methodology.	√	√	
ISO	Compilation of standards to be used for data harmonisation.	Use the RISE M&G document as part of the foundation for its continued work. ISO could, possibly, carry forward the RISE methodology amongst its members, on its website and in its various technical working groups, in particular the ones working on the draft standard for data exchange.	ISO can, in its continued work, build on the experience that has been gained through the RISE project and thus do not need to repeat this work. RISE has tested and promotes several ISO standards via the RISE methodology.	√		

Harmonisation and Standardisation Initiative	Description of harmonisation activities likely needed	Possible use of Methodologies and Guidelines (M & G) document	Potential benefits	Efficiency Benefit	Effective-ness Benefit	Social-Political Benefit
CEN	Compilation of standards to be used for data harmonisation.	Use the RISE M&G document as part of the foundation for its continued work. CEN could, possibly, carry forward the RISE methodology amongst its members, on its website and in its various technical working groups.	CEN can, in its continued work, build on the experience that has been gained through the RISE project and thus do not need to repeat this work.	√		
The EC	The European Commission and in particular DG-ENV are a very important stakeholder with respect to streamlining of reporting in the context of various EC directives. The development of harmonised data specifications is a key part in the streamlining processes			√	√	√

4.4. ESA and EU FP6 / FP7 Projects

RISE has been in touch with many ESA/EU-funded projects addressing harmonisation issues. The most relevant projects are listed below. The projects can benefit from the RISE results through uptake of the Methodologies and Guidelines in their own work as well as networking with RISE Partners for future activities, leveraging the gathered expertise in the RISE consortium.

ESA and EU FP6/FP7 Project	Description of harmonisation activities likely needed	Possible use of Methodologies and Guidelines (M & G) document	Potential benefits	Efficiency Benefit	Effective-ness Benefit	Social-Political Benefit
The MOTIIVE project	Examine the cost benefit of using non-proprietary data standards while addressing data harmonisation requirements between the INSPIRE data component “elevation”, “sea regions”, “oceanic spatial features” and “coastal zone management areas”.	According to the project contract, MOTIIVE has tested the usage of the RISE methodology in their work.	Provided that the RISE methodology is proven to work by MOTIIVE, this will bring benefits to the marine community because it can build upon the experience gained through the RISE and MOTIIVE projects.	√	√	
The HUMBOLDT project	Has the aim to manage and advance the implementation process of the ESDI. The main goal is to enable organisations to document, publish and harmonize their geospatial data.	The RISE M&G document could be used when they develop harmonised data specifications for some scenarios in their WP7. Eurogeographics has agreed to participate in the Advisory Board	HUMBOLDT can, in its work, build on the experience that has been gained through the RISE project and thus do not need to repeat this work.	√	√	

ESA and EU FP6/FP7 Project	Description of harmonisation activities likely needed	Possible use of Methodologies and Guidelines (M & G) document	Potential benefits	Efficiency Benefit	Effective-ness Benefit	Social-Political Benefit
WISE	Develops a system for data upload, sharing and analysis of requirements for the WFD.	WISE has already developed a portal for uploading, sharing and analysis and it's thus not likely that the M&G document will be of any use.	Possibly, the M&G document could be used in future upgrades	√		√
GSE Land	The overall goal is to implement a European service network responding to the demand of international, national, regional and local user organisations.	Use the RISE M&G document as part of the foundation for its work.	GSE Land can, in its work, build on the experience that has been gained through the RISE project and thus do not need to repeat this work.	√	√	

4.5. End Users

In the context of the RISE Use Cases, the end user community is limited to data integrators and data providers, since the project focussed on input data to a modelling process. However, in general this community includes a range of target groups up to the general public, where for the first time in this comparison an impact in terms of social-political benefits can be expected. The creation and subsequent availability of harmonised geographical data products will very likely improve access to information, thus leading to more transparent and accountable governance, better collaboration between stakeholders within and outside government and also new research and business opportunities.

The following table lists a number of the key stakeholder communities that belong to this group:

End User	Potential benefits using harmonised geographical data	Efficiency Benefit	Effective-ness Benefit	Social-Political Benefit
The EC	Needs harmonised geographical data on a pan-European level for planning and evaluation purposes. Harmonised geographical data is a must for implementing the INSPIRE Directive.	√	√	√
National and regional authorities	Need harmonised geographical data for better planning and modelling, and for preparing data for EC reporting.	√	√	√
Non Governmental Organisations	For instance, Greenpeace and the Red Cross would profit from easily available harmonised geographical data in their environmental evaluations and first aid planning.		√	√
General public	The general public would profit from easily available harmonised geographical data.		√	√

5. Validation

The process outlined by RISE in this document identifies the areas which need to be considered in detail for a quantitative and qualitative case by case study of costs and benefit factors in implementing the RISE methodology. By outlining the necessary steps and related efforts, a third party will be able to do a cost estimate based on its very own internal structure, processes and procedures as well as financial framework. In the same way the benefits are outlined on a generic level in chapter 3, thus allowing an organisation to calculate e.g. potential savings on the production side or gains due to newly addressable market segments based on their very own cost structures and marketing strategies.

This approach taken by RISE regarding the Cost Benefit documentation has been discussed with the RISE advisory board and selected use case participants, i.e. the stakeholders in Sweden and Norway, who are involved in reporting to the EC in the context of the WFD.

These stakeholders should ideally have picked up the present process and worked through quantifying the methodology steps outlined in this RISE approach as relevant to CBA considerations for data harmonisation for the specific WFD application. Such a validation with the RISE Test environment in place would then illustrate the applicability of the process for implementation of the RISE methodology towards more efficient processing and cost reduction in data product harmonisation. However, due to resource constraints, a validation of this type could not carried out.

Nonetheless, to give an idea about some actual calculations related to several CB factors identified by the RISE approach, two examples of CBAs are provided in this document:.

The first case is presented by the Swedish RISE participant, NLS. The CBA is looking at the implementation of the Swedish Surface Water Standard for the hydrography data existing in Sweden and used for WFD reporting. The standard is developed following ISO standards and supports the reporting of surface water features to the WFD.

In the appendix of this document, the RISE Project partner BRGM provides a CBA for the introduction of the IDPR index methodology. The elevation data input processing for that index calculation has been described in the RISE Use Case document [2]. The CBA for the IDPR deals with the introduction of the IDPR methodology and thus provides an example of costs and benefits associated with the implementation of a methodology. Although it is not a validation of (aspects of) the RISE approach (as is the Swedish example), the illustration of the IDPR example can, in general, give an indication for actual values for putting into practice other examples like the RISE one.

5.1. Identification of preliminary costs and benefits associated with Lantmäteriet's adoption of the Swedish Surface Water Standard

5.1.1. Introduction

Many harmonisation efforts today are being performed without using any methodology. For example, Lantmäteriet, the Swedish National Land Survey (NLS) has performed a test to find out how the existing hydrological data match with the Swedish Surface Water Standard (SSWS)[18], and also, where it does not match, describe what activities needed to make it match. These tests are a “real life” experience on what it takes to harmonise hydrological data to a given standard, and the associated costs and benefits. This work has recently started so the findings presented below must be regarded as very preliminary.

5.1.2. First Priority Actions

The purpose of this standard is, on one hand, to make it possible to exchange geographic information about lakes, watercourses and surface water systems and, on the other, to be part of national and international initiative concerning harmonisation of geographical information, e.g. the EC framework directives for water and INSPIRE.
The SSWS has a complex structure and only parts of it concerns NLS. The test has shown that to conform to the standard, NLS must do at least the following changes to its existing data:

- Divide the water bodies into rivers and lakes
- Find out the flow direction for rivers that are represented as lines
- Create inlets and outlets as points
- Assign a unique id to each object
- Add version id to each object
- Start the implementation of a logical river network

5.1.3. Preliminary Identification of Costs and Benefits

The purpose is to describe the economical effects a standardisation will bring and then relate them to the cost of the implementation so that the net benefit can be calculated. The table below gives a first, very preliminary result of the on-going work.

The annual **current** direct running costs are estimated at 110.000 SEK (~ 12.000 €) and the **future** investment needed for standardisation of hydrographical data is estimated at 3.200.000 SEK (~350.000 €).

Efficiency benefits (A), Effectiveness benefits (B), Social-political benefits (C)	**A**	**B**	**C**	**Net effect**	**Net effect, SEK, %**
Quantifiable benefits for Lantmäteriet					
More efficient processes and administration as all objects will have an unique ID	X	X		Lower costs by more efficient administration cost savings	**NLS** cost savings on administration with 20% or 20.000 SEK
More cost efficient information flow due to standardised exchange format	X	X		More cost-effective provision of services with a new standard	**NLS** reduction of costs for provision of services with 15 %, i.e. 15.000 SEK
More market oriented hydrographical products	X	X	X	Increased sales	**NLS** potential increase of revenues: 3.000.000 SEK over 3 years.
Qualitative benefits					
More effective administration of water			X	Benefits for Swedish water authorities and local authorities	Difficult to quantify
Simplified data exchange with other systems	X	X	X	The data exchange between different stakeholders will be simplified by using a standardised format	Difficult to quantify
Better quality of the data	X	X	X	Will increase and broaden the use of GIS data	Difficult to quantify
More effective pooling of interests	X	X	X	Simplified co-operation between authorities, local, national and international	Difficult to quantify
Increased legal security			X	Data correctly interpreted for water courts etc	Difficult to quantify
Facilitated development of new products		X		Increased revenue for data integrators	Difficult to quantify

Benefits to NLS as a Data Provider
The NLS benefits are divided into three groups depending on what economical effect they will produce. They will be estimated and a reasonability assessment will be done:

- Benefits with a direct affect on the operating result, e.g. more efficient processes
- Benefits with an indirect affect on the operating result. Those benefits are more uncertain and will only take effect when other actions have been taken, e.g. investments in system development for provision of data.
- Benefits that are difficult to quantify, they are very uncertain and are often described in qualitative terms

As stated above, the current running costs are approx 110.000 SEK. If the defined actions are taken, the running costs will be reduced by some 30 %, due to increased efficiency.

The estimated increase of revenues from new, harmonised hydrographical products is estimated to around 3.000.000 SEK over a three-year period.

Benefits to Data Integrators and End Users
The external benefits are very difficult to quantify, without more detailed market studies. However, in a study from the Swedish Development Council for Geographic Information (ULI 2005:1), a market research has been performed on users of geographical information, where questions about hydrographical data also were included. Out of the 700 organisations that answered the questions, 350 organisations used surface water data and catchment areas. The research showed a broad use of the data within most of the organisations.

Easily available and correct hydrographical data is also important for many actors of service to society, e.g. for risk management.

Given the above facts, it's obvious that the proposed standardisation will add a significant value to the users.

5.1.4. Conclusions

If only cost savings are considered, the pay-off time for NLS would be almost 100 years, using 5% interest rate. The investment is therefore unprofitable unless the anticipated increase of income is taken into account.

As there will be new, improved and harmonised hydrographical products and services, there will also be a new and increased demand, estimated to approximately amounting to around 3.000.000 SEK over a three-year period. This means that the pay-off time for the investment would be three years, which can be seen as a self-financing investment.

If also the social-political benefits are added into the calculations, the value of the harmonisation can be seen even more clearly. It can be assumed that the investment will create many additional values to society and is therefore also motivated from a public economy point of view.

6.Conclusions and Recommendations

The RISE Methodology and Guidelines document provides a method for data harmonisation that can guide the stakeholders, data providers and integrators alike, in their work.

The actual benefits of following the RISE Methodology and to justify the investment in an internal cost benefit analysis, which in turn may trigger the adoption of the Methodology, will vary with each scenario: each data theme can serve a number of use case scenarios, involving various processing entities and likely a number of different user segments. The key benefits thus need to be identified for each actor in the use case and should be documented according to the following three categories:

- Efficiency Benefits
  The general benefits that data product harmonisation provides have been identified based on the user requirements, the creation of sample specifications and the validation with end users. Analysing the user requirements for a data theme and the associated processes and procedures allocated to the production of this data provides an ideal basis to document the costs and efforts involved in the existing operations and to identify areas which may benefit e.g. from a re-organisation of the process flow or the introduction of process automation.

  The key benefit to be derived from a use case analysis will be in the area of process optimisation, potentially leading to reduced costs.

- Effectiveness Benefits
  The Use Case Documentation not only provides the basis for an optimisation of the processes and procedures from an efficiency point of view, but also offers effectiveness benefits: improved integration of data, services and IT platforms can lead to easier access to relevant information for the users, according to their (documented) requirements and open up new market segments.

  From a CBA's point of view the scope of the Use Case Documentation should be complemented by a market review, considering relevant policies and market forces which may also have an impact on the final data products in addition to the user requirements.

- Social-Political Benefits
  Whilst Efficiency and Effectiveness Benefits constitute commercial reasons to commission a User Requirements Documentation, Social and Political Benefits are of a more intangible nature and only served indirectly, once harmonised products are available, together with potential new application areas and markets.

  However, this category can provide valuable input to the long-term business strategies of data suppliers and data processors, supporting the implementation of policies and sustainable operations alike.

The CB factors associated with the implementation of the RISE approach have been presented in a process description. This provides guidance for stakeholders on analysing their potential costs and benefits from harmonising data, but also helps them to build an improved understanding for individual business cases through the development of detailed use case scenarios.

As an item for future R&D projects it is suggested to incorporate detailed CBA and Impact Assessment activities as significant activities that accompany related data harmonisation projects, to support the uptake of the RISE Methodology.

Appendix

A.1. CBA for the implementation of the IDPR

It is anticipated that the RISE CBA approach can support an organisation to make the decision to create harmonised datasets. However, whilst this decision is supported by the generic benefits RISE has been able to identify and the general effort estimates as experienced in RISE, the provided approach sets the frame for the actual Cost Benefit Analysis, which should be applied to the specific case, accounting for the individual organisations parameters.

To underline some cost benefit factors pointed out in the RISE approach in terms of introduction of a methodology, the cost-benefit analysis applied to the French Indice de Développement et de Persistence des Réseaux (IDPR) also named SUrface water/ GroundwAter contRibution index (SUGAR) described in the RISE Use Case document, has been examined. The focus of the IDPR CBA described in the following chapters is on the implementation of the IDPR tool offered by BRGM as such. Instead of the cost and benefits involved in harmonised data product specification, the IDPR tool looks in a more abstract way at those related to the IDPR tool introduction and application.

The IDPR methodology has been created by BRGM to carry out national or regional maps of vulnerability that may for instance contribute to the establishment of the priorities of monitoring and interventions in the context of the implementation of the Water Framework and the Groundwater directives [9]. Until now this methodology has been applied at the regional and river basin district level (in France), at the national level (France, Slovenia) and is being developed at the European level especially through the European Footprint project[1].

A.2. Methodological Framework

The following methodological steps have been developed and their relationships are illustrated by Figure 1:

- *State of the Art.* Brief literature review of cost-benefit analyses applied to SDI: INSPIRE extended impact assessment [10], economic analysis developed within the MOTIIVE project[2], impact assessment of various SDIs [7] etc. Brief literature review of IDPR applications and alternative tools used in European countries.

- *Key experts' consultation.* Key experts' consultation (meetings with BRGM's researchers and phone interviews with external experts): stakeholders involved in the implementation at the river basin district level (AERM, AELB, AERMC), at the administrative regional level (Nord Pas de Calais Region), at the national level (France, Slovenia) and at the European level (in the framework of the Footprint project).

- *Identification of potential end-users and data providers.* Identification and typology of the main data providers and potential IDPR users communities that could be concerned by costs/ benefits (who are the potential winners/ losers?) related to the implementation of the IDPR methodology (European Commission, national mapping agencies, national environment agencies and geological surveys, regional and local authorities, citizens, private sector data users, research institutes, etc).

- *Identification of costs and benefits.* Typology of costs and benefits resulting from the IDPR implementation (past or potential in the future) that could occur for each users/ providers identified in the previous step (What kind of costs/ benefits? For what? Who will bear the costs? Etc.).

---

1 http://www.eu-footprint.org/home.html

2 http://www.eucc.net/en/policy/index.htm

- *Cost-Benefit analysis.* Quantification (when possible) of costs and benefits related to the implementation of the IDPR methodology and the harmonisation at European scale. Comparison between costs and benefits, taking time into account.

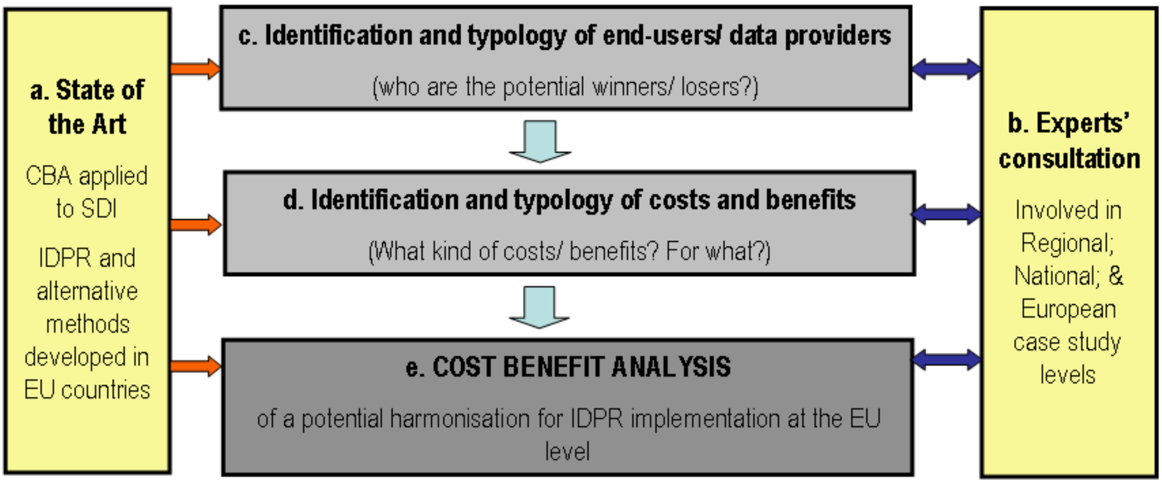

Figure 1. Proposed methodological steps

In addition to the work carried out to develop the RISE CBA approach, the following recommendations made by the EC (2006) have supported the development of the CBA methodological framework for the IDPR Use Case:

- *Recommendation n°1:* "To develop a shared portfolio of studies at different levels of granularity: the micro level (e.g. time saving, expenditure reduced avoided within organisations), meso-level (cross organisational, regional, sectoral), and macro-level (national or international comparative studies, cross-sectoral studies) and build the knowledge of assumptions made, assessment methods and outcomes."

- *Recommendation n°4:* "To develop a theoretical framework underpinning the identification of SDI benefits (i.e. what kind of benefits, both positive and negative, would we expect and why from a SDI)."

- *Recommendation n°5:* "To pay particular attention to identifying user communities, and eliciting their assessment of value deriving from a SDI."

As the methodological framework used for carrying out cost benefit analysis of the national map [7] appeared to be the most relevant for cost-benefit analysis of IDPR, it has been adapted and completed by concepts related to value of information ([11], [12]) for the design of the methodological framework.

A.3. IDPR Use Case

A.3.1 Description

The Indice de Développement et de Persistance des Réseaux (IDPR)/ SUrface water - GroundwAter contRibution index (SUGAR) is a simplified approach to assess the tendency of a catchment to transfer water to groundwater (infiltration) or to surface water (run off). The methodology is based on the comparison of an artificial drainage network obtained using the Digital Elevation Model (DEM) and the real drainage network using hydrography data set. For a detailed technical description of the method in the framework of the RISE project, please refer to the RISE Use Case document [2].

Until now, as the implementation of several European directives requires the assessment of the vulnerability of groundwater bodies, the main application of the IDPR consists in using it for assessing groundwater vulnerability (with the use of data on thickness of unsaturated zone). This index may also be used for assessing surface water vulnerability (with the use of data on slopes and on thickness of unsaturated zone). To simplify the framework of this report, we will consider the IDPR through its use for groundwater vulnerability assessment.

A.3.2 Types of application

As it will be further described in chapter 3, benefits of IDPR development and harmonisation come mainly from the benefits provided by its potential applications: for a given application, the use of IDPR may permit, facilitate of improve some public or private decision of process. Therefore, the main types of application using IDPR need to be understood. The use of IDPR to produce groundwater vulnerability map can help:

- To undertake vulnerability assessment for water bodies (knowledge, awareness building) and characterise the natural groundwater protection required by the EU Water Framework Directive.
- To design and optimise monitoring network: in general, more vulnerable aquifers of parts of aquifer will require greater monitoring efforts and therefore aquifer vulnerability mapping can provide a means for prioritising monitoring efforts [13]. The IDPR can be used for instance to help water managers in the implementation of WFD regarding the division of groundwater body into sectors, the design of monitoring network and the assessment of their validity..
- To assess the chemical status of groundwater bodies: the Groundwater Daughter Directive (2006/118/EC) adopted in accordance with Article 17 WFD requires the assessment by Member States of groundwater chemical status with the monitoring programmes that have just become operational and, where necessary, establish programmes of measures to be included in the WFD River Basin Management Plans (RBMPs, see below).
- To design programme of groundwater management measures to be included in WFD RBMPs: vulnerability maps help to focus pollution prevention programmes on areas of greatest concern. This could help the implementation of effective programmes of measures required by various European directives (WFD, Groundwater directive, Nitrate directive) as well as the European Rural Development Programme (e.g. agri-environment schemes) or the French national plan to reduce pollution by pesticides.

These applications are in close link with the requirements of the WFD. Although vulnerability maps may be used for other policy implementation (Nitrate directive, French national plan to reduce water pollution due to pesticides, management of contaminated sites, etc), we will focus this report on the potential applications of IDPR in the context of the implementation of the WFD.

The Water Framework Directive sets out clear deadlines for each of the requirements - the key milestones are listed below: [3]

Year	Issue	Reference
2000	Directive entered into force	Art. 25
2003	Transposition in national legislation Identification of River Basin Districts and Authorities	Art. 23 Art. 3
2004	Characterisation of river basin: pressures, impacts and economic analysis	Art. 5
2006	Establishment of monitoring network Start public consultation (at the latest)	Art. 8 Art. 14
2008	Present draft river basin management plan	Art. 13
2009	Finalise river basin management plan including progamme of measures	Art. 13 & 11
2010	Introduce pricing policies	Art. 9
2012	Make operational programmes of measures	Art. 11
2015	Meet environmental objectives	Art. 4
2021	First management cycle ends	Art. 4 & 13
2027	Second management cycle ends, final deadline for meeting objectives	Art. 4 & 13

A.3.3 Relevant scale(s) for IDPR applications

In the context of the WFD, three levels of applications may be distinguished and should be considered for cost benefit analysis:

- The national River Basin District (RBD) or national part of an international RBD level: in charge of WFD implementation;
- The Member State level: in charge of transposition of WFD into national legislation, of harmonisation and reporting to the European level;
- The European and international RBD level: international RBD establishment between Member States is required by Article 3 WFD.

At national and international RBD level, the major direct end-users are water managers involved in WFD implementation. At national and European scale groundwater vulnerability mapping may be relevant to policy makers and registration authorities.

[3] http://ec.europa.eu/environment/water/water-framework/info/timetable_en.htm

A.3.4 Examples of Applications

Until now, IDPR has been used for groundwater vulnerability assessment and has been mainly applied at three scales: (i) regional and river basin district (RBD) level, (ii) national level, (iii) European level.

<table>
<tr><th>Scale</th><th>Location</th><th>Objective</th><th>Year</th><th>End users</th><th>Data providers for IDPR</th></tr>
<tr><td>Regional / RBD</td><td>La Réunion (France), plaine des galets</td><td>Vulnerability map</td><td>1999</td><td></td><td rowspan="8">IGN:
- MNT 1/50,000 from BD ALTI
- hydrographic network 1/50,000 from BD CARTHAGE</td></tr>
<tr><td>Regional / RBD</td><td>Nord Pas de Calais (France)</td><td>Vulnerability map</td><td>2002</td><td>Nord pas de Calais Region, DIREN, ADEME</td></tr>
<tr><td>Regional / RBD</td><td>Bassin Seine-Normandie (France)</td><td>Vulnerability map
Crossing with BASOL database
Design of monitoring network</td><td>2006</td><td>AESN, MEDD, DRIRE, DIREN</td></tr>
<tr><td>Regional / RBD</td><td>Bassin Loire-Bretagne & Region Pays de la Loire (France)</td><td>Vulnerability map
Design of monitoring network</td><td>2005</td><td>AELB, Pays de la Loire Region</td></tr>
<tr><td>Regional / RBD</td><td>Aquitaine (France)</td><td>Vulnerability map</td><td>2005</td><td>Region Aquitaine</td></tr>
<tr><td>Regional / RBD</td><td>Basin Rhône Méditerranée Corse</td><td>IDPR</td><td>2002</td><td>AERMC</td></tr>
<tr><td>Regional / RBD</td><td>Bassin Rhin-Meuse</td><td>Vulnerability map</td><td>2007</td><td>AERM, DIREN, DRAF</td></tr>
<tr><td>National</td><td>France</td><td>Harmonisation of vulnerability maps in France</td><td>2007</td><td>MEDD</td></tr>
<tr><td>National & Regional</td><td>Republic of Slovenia</td><td>Vulnerability map,
Groundwater bodies delineation</td><td>2003</td><td>Environmental Agency of the Republic of Slovenia
EU (LIFE)</td><td></td></tr>
<tr><td>EU</td><td>Europe (25)</td><td>Vulnerability map</td><td>2007</td><td>EU (6th FP)</td><td>- SRTM for DEM 1/90,000
- Digital Chart of the World (DCW) for hydro 1/1,000,000</td></tr>
</table>

Figure 2. Existing applications of IDPR

A.4. CBA Methodology Framework

A.4.1 Main assumptions

- The distinction between the costs and benefits of IDPR itself from those of the application of the IDPR should be made.
- Cost benefit analysis of IDPR requires the comparison of a situation *with* the IDPR from that *without* (*without* can be the situation without any equivalent tool or with an equivalent tool).
- As mentioned by Halsing *et al.* [7] we will assume that values come from applications. The value (or net benefit) of IDPR is equal to the discounted summation of the changes in net benefits of the application minus the cost of the method.

- IDPR can be applied at several geographic levels[4]: (i) river basin district (RBD)[5]; (ii) national level; (iii) European and international RBD level. Types of application, their related costs and benefits, potential end-users will differ from a scale to another. CBA should thus take into account net benefits that could occur at each level.

- As mentioned earlier, types of applications of IDPR are numerous. We will focus here on applications using IDPR as a tool for assessing groundwater vulnerability in the context of implementation of the WFD.

A.4.2 Basis for comparison

The comparison will be made between the situation *with* and that *without* IDPR. For this purpose, three scenarios/ alternatives will be considered:
Alternative A describes the situation *with (*implementation of IDPR method to assess groundwater vulnerability). The situation *without* can be described by *Alternative B* (implementation of an alternative tool to assess groundwater vulnerability) or *Alternative C* (no attempt to assess groundwater vulnerability).
CBA may be carried out by comparing Alternative A with Alternative B or by comparing Alternative A with Alternative C, according to the context. This comparison between two alternatives should be made for each type of application at each scale.

A.4.3 Economic model for estimating net benefits

At the RBD level (R_j *)*, we consider that the value (or net benefit) $NB_{IDPR}^{R_j}$ of IDPR is equal to the benefits $B_{IDPR}^{R_j}$ of the information it provides minus the cost $C_{IDPR}^{R_j}$ of the method.

$$NB_{IDPR}^{R_j} = B_{IDPR}^{R_j} - C_{IDPR}^{R_j} \qquad (1)$$

The benefit of the IDPR is the summation of the changes in net benefits of the applications. Define $Y_i^{R_j}$ as the net benefit of the IDPR as used in an application i at the R_j level:

$$NB_{IDPR}^{R_j} = \sum_i Y_i^{R_j} - C_{IDPR}^{R_j} \qquad (2)$$

Define $NB_{i(with)}^{R_j}$ as the net benefits of the application i with the use of IDPR and $NB_{i(without)}^{R_j}$ as the net benefits of the same application without the use of IDPR. The net benefit of the IDPR as used in the application i can be written:

$$Y_i^{R_j} = NB_{i(with)}^{R_j} - NB_{i(without)}^{R_j} \qquad (3)$$

Define $y_i^{R_j}(t)$ as the net benefit at time t, T as the time horizon of interest, a as the discount rate. As $Y_i^{R_j}$ is a discounted summation of the annual net benefits of the use of IDPR in the application i, it can be also written:

$$Y_i^{R_j} = \sum_{t=1}^{T} \frac{y_i^{R_j}(t)}{(1+a)^t} \qquad (4)$$

$C_{IDPR}^{R_j}$ is the difference between cost $C_{(with)}^{R_j}$ of the vulnerability map build with IDPR (cost of the map itself, not of the applications in which it is used) and cost $C_{(without)}^{R_j}$ of the alternative tool that could be used in the situation without IDPR (if alternative B).

$$C_{IDPR}^{R_j} = C_{(with)}^{R_j} - C_{(without)}^{R_j} \qquad (5)$$

[4] According to Gravier *et al. [15]* the spatial scale recommended for the use of IDPR is 1/100,000 (with DEM and hydrography data available at 1/50,000)
[5] Here we consider national river basin districts (RBDs) or national parts of international RBDs.

Define $c_{IDPR}^{R_j}(t)$ as the cost at time t. As $C_{IDPR}^{R_j}$ is a discounted summation of the annual costs, it can be also written:

$$C_{IDPR}^{R_j} = \sum_t \frac{c_{IDPR}^{R_j}(t)}{(1+a)^t} \qquad (6)$$

At the national level (N_k), we consider that the net benefit $NB_{IDPR}^{N_k}$ of IDPR is the summation of net benefits at RBD scale plus the net benefit $NB_H^{N_k}$ provided by the harmonisation at the national scale.

$$NB_{IDPR}^{N_k} = \sum_{R_j \in N_k} NB_{IDPR}^{R_j} + NB_H^{N_k} \qquad (7)$$

The net benefit $NB_H^{N_k}$ of IDPR harmonisation at the national level is equal to the benefits of the information it provides (summation of the changes in net benefits of the applications) minus the cost $C_H^{N_k}$ of the harmonisation. Define $Y_i^{N_k}$ as the net benefit of the national harmonisation as used in an application i at the N_k level:

$$NB_H^{N_k} = \sum_i Y_i^{N_k} - C_H^{N_k} \qquad (8)$$

At the European level (EU), we consider that the net benefit $NB_{IDPR}^{EU_k}$ of IDPR is the summation of net benefits at the national level plus the net benefit NB_H^{EU} provided by the harmonisation at the European level.

$$NB_{IDPR}^{EU} = \sum_{N_k \in EU} NB_{IDPR}^{N_k} + NB_H^{EU} \qquad (9)$$

The net benefit NB_H^{EU} of IDPR harmonisation at the European level is equal to the benefits of the information it provides (summation of the changes in net benefits of the applications) minus the cost C_H^{EU} of the harmonisation. Define Y_i^{EU} as the net benefit of the European harmonisation (including benefit for international RBD) as used in an application i at the EU level:

$$NB_H^{EU} = \sum_i Y_i^{EU} - C_H^{EU} \qquad (10)$$

A.5. Assessing the Costs

From *(5)*: $$C_{IDPR}^{R_j} = C_{(with)}^{R_j} - C_{(without)}^{R_j}$$

At the regional level, the cost $C_{IDPR}^{R_j}$ is the difference between the costs for obtaining a groundwater vulnerability map with or without the use of IDPR. $C_{(with)}^{R_j}$ is the cost of alternative A and $C_{(without)}^{R_j}$ is the cost of alternative B or C. The same thought process may be applied for assessing $C_H^{N_k}$ at the national scale or C_H^{EU} at the European scale.

Moreover, distinction should be made between cost of implementation (at the regional or RBD level) and cost of harmonisation (at the national, European or international RBD level). Main types of costs identified for IDPR/ other tool implementation and harmonisation are the following:

- ❖ Costs to apply the methodology (personnel, staff time) for vulnerability map production: cost required for calculation, production of a map and explanatory leaflet, at regional level mainly (we assume that the process starts at the regional level).
- ❖ Costs related to the coordination (training, consultation meetings for validation with end-users): regional, national and EU scale

- ❖ Costs related to the harmonisation of vulnerability maps (personnel, staff time): national and EU level.
- ❖ Costs related to data acquisition: for instance cost for acquisition of hydrography (1/50,000) and DEM (1/50,000) for IDPR.

It is assumed that after development and validation of the tool, no additional annual costs are likely to occur. Moreover, it is assumed that final groundwater vulnerability maps will be accessible for free by internet to each potential end-user.

A.6. Assessing the Benefits

A.6.1 Two major types of benefits

"It is widely recognised that, in the few CBA undertaken of Spatial Data Infrastructure Policies, the quantification of benefits is particularly challenging" [6]. The aim of this chapter is to propose a theoretical framework for assessing benefits as recommended by the EC [8]. Two different forms of benefits which are generally quoted in the literature, efficiency and effectiveness benefits have been mentioned before in the main document (see chapter 2.1).

For instance, effectiveness benefits related to environmental policy implementation may consist in improving environmental reporting, environmental and other impact assessments, site and area selection, establishment of management plans for specific sites or areas, implementation of registration requirements related to territorial factors, establishment of permits that need to take into account territorial factors, notification requirements and public information, establishment of monitoring networks, etc [6].

A.6.2 Information value

Efficiency and effectiveness benefits of IDPR applications are closely linked to the concept of the value of information. We will assume that the benefits of the IDPR method come from the value of information as this index is used to permit, facilitate, or improve some public or private decision or process (in reference to CBA applied to the National Map by Halsing *et al* [7]). As mentioned by Boyd [11], information itself has little intrinsic value. Instead, information acquires value when it facilitates optimising behaviour and leads to decisions different from those that would be made in the absence of the information. The benefits of an application are the net present value of end-user ability to improve a decision's effectiveness and/or efficiency with the use of IDPR in a way that was not previously feasible.

Depending on the specific application and the place it is being implemented, having the IDPR available for decision making can either reduce the costs of the application (an efficiency gain/ cost savings) or increase the economic[6] and/or environmental[7] benefits (an effectiveness gain/ added value).

A.6.3 Framework for assessing information value

To illustrate the value of information that could be brought by IDPR, let us take a theoretic example. This will set the framework for assessing net benefits that could occur through the use of IDPR for the implementation of the programme of measures required by the Water Framework Directive. Groundwater bodies classified at risk require implementation of measures to improve groundwater quality. However, in order to be effective, these measures should be implemented in relevant areas (where groundwater is vulnerable and pressures are high). Implementation of measures on the whole surface area covering the groundwater body at risk may lead to measures and costs for reducing pressures that are ineffective. On the other hand, a detailed assessment of groundwater vulnerability may be a long process and lead to a delayed improvement of groundwater quality.

[6] Benefits that society, a firm, a researcher, or an individual can reap from the application [7]

[7] In cases where information pertains to the environment, the output can be expressed in terms of measures of the value of environmental quality or the value of damage avoided thanks to actions that may be taken in light of the information [14]

The basic assumption is that the use of vulnerability map based on IDPR method will deliver additional (new) information on the groundwater body vulnerability that will improve decision making, preventing for example wrong decisions for the design of future monitoring programmes or for the implementation of the programme of measures aimed at improving water status (in reference to CBA applied to SMETs by Graveline *et al.* [12]). In this case, expected benefits of IDPR applications can be expressed in terms of environmental benefits (value of improvement in groundwater quality or value of damage avoided thanks to actions that may be taken in the light of IDPR information).

For a given groundwater body with high vulnerable and low vulnerable zones in which a programme of measures should be implemented, each situation presented in Figure 3. will have a probability to exist (from p_1 as the probability to implement an action in a vulnerable zone to p_4 the probability of not implementing action in a non vulnerable area, the sum of the four probabilities being equal at 1).

Define E as the environmental benefits (discounted sum) related to the improvement of groundwater resources by reaching the good chemical status. Define M as the costs (discounted sum) of the implementation of measures to improve groundwater status. T is the time period between now and the time of implementation of the measures: this time period may vary from an alternative to another. Z is the transfer time from the soil to groundwater: environmental benefits start to exist a time period Z after the time T of measures implementation. C_i^x and B_i^x are respectively the costs and benefits resulting from the decision i that is made and are associated to the probability of occurrence p_i^x.

From *(3)*: $Y_i = NB_{i(A)} - NB_{i(B)}$ or $Y_i = NB_{i(A)} - NB_{i(C)}$

Bayesian formula allows determining net benefits for each alternative (see Annex 2 for an overview of the Bayesian theory):

$$NB_{i(x)} = \frac{p_1^x \cdot (B_1^x - C_1^x) + p_3^x \cdot (B_3^x - C_3^x)}{p_1^x + p_3^x} + \frac{p_2^x \cdot (B_2^x - C_2^x) + p_4^x \cdot (B_4^x - C_4^x)}{p_2^x + p_4^x} \qquad (11)$$

Alternative	GW vulnerability (not known)	Decision	Probability (p_i^x)	Costs (C_i^x)	Benefits (B_i^x)
A	Yes	Action	p_1^A	M_{T_A}	E_{T_A+Z}
		No action	p_2^A	E_{T_A+Z}	-
	No	Action	p_3^A	M_{T_A}	-
		No action	p_4^A	-	-
B	Yes	Action	p_1^B	M_{T_B}	E_{T_B+Z}
		No action	p_2^B	E_{T_B+Z}	-
	No	Action	p_3^B	M_{T_B}	-
		No action	p_4^B	-	-
C	Yes	Action	p_1^C	M_{T_C}	E_{T_C+Z}
		No action	p_2^C		
	No	Action	p_3^C	M_{T_C}	-
		No action	p_4^C		

Figure 3. Costs and benefits related to each alternative of the application

Benefits of IDPR are the sum of net benefits related to the applications of IDPR. Assessing the benefits of IDPR would thus require the same analysis as described above for each application.

From *(2)*: $$B_{IDPR}^{R} = \sum_{ij} Y_{ij}^{R}$$

Ideally, it would be possible to make an exhaustive search for a large number of applications that had been improved with IDPR and determine the difference in net benefits of those applications thus recognized. Those observations would then be used to extrapolate the net benefits that would be weighted against the costs of developing the IDPR and a net benefit for the programme can be estimated (adapted from [7]).

A.7. Analysis framework for IDPR applications in France

A.7.1. General Framework

From *(7)*: $$NB_{IDPR}^{France} = \sum_{R_j \in France} NB_{IDPR}^{R_j} + NB_{H}^{France}$$

From *(8)*: $$NB_{H}^{France} = \sum_{h} Y_{h}^{France} - C_{H}^{France}$$

From *(2)*: $$NB_{IDPR}^{R_j} = \sum_{i} Y_{i}^{R_j} - C_{IDPR}^{R_j}$$

A.7.2 Analysis of the application at the River Basin District level

A.7.1.1 Overview: End users, data providers, potential applications

At the RBD level, the main end-users of the use of IDPR for groundwater vulnerability assessment are likely to be the Water agencies. Administrative bodies and other organisations may also be interested (for instance DRIRE, DIREN, DRAF, MISE, GRAPPE, Chambres d'Agriculture, PNR). IGN is the unique data provider for DEM and hydrography data.

Main applications at the RBD level in the context of the WFD implementation are likely to be the design of the monitoring network, the design of the programme of measures and the assessment of groundwater chemical status are expected to be facilitated by the use of IDPR.

A.7.1.2 Advantages

- Low cost and fast development: in comparison with other methodologies of vulnerability assessment that are generally costly in time and data, the IDPR method is quite simple to apply until it requires few data. Moreover, this method is based on data that water managers can be expected to have collected for the WFD reporting. According to data gathered in the framework of the study, we assume that IDPR requires 1 year to be develop, applied and validated at the RBD scale (in comparison with at least 3 years for classical tools like DRASTIC for instance). For a comparison between alternative A and B, costs savings are important regarding the development of the method and time savings may have a great impact on environmental benefits (earlier implementation of effective monitoring network and programme of measures).

- Homogeneous method covering the whole river basin: facilitate a common vision of groundwater vulnerability at the river basin scale around experts from various administrative sectors/ disciplines. Before developing a simplified method to assess groundwater vulnerability, it was generally stated that within the river basin data about groundwater vulnerability were either non-existent in some areas or too heterogeneous from an area to another for being used at the river basin scale (see for instance Gravier *et al.* [15]). For a comparison between alternatives A and C, design of monitoring network and programme of measures is likely to be less time-consuming if stakeholders involved in the implementation of WFD have a common vision of the RBD.

- Allow the division of groundwater bodies into sectors that facilitate the implementation of programmes of measures (improvement of the cost-effectiveness) and the design of monitoring network (improve the representativeness). For a comparison between alternatives A and C, environmental benefits are expected to be higher and money is expected to be spent in a more effective way.

- Good accessibility (free download) and easy use the GIS tools for experts with sufficient GIS & hydrology knowledge.

A.7.1.3 Disadvantages

- Time needed for consultation and validation: vulnerability maps need to be validated by local expertise and some disagreement with local experts may occur. This process needs to be taken into account for the assessment of the cost of IDPR application: time required for consultation of local experts, for regular meeting of the follow-up committee (mainly composed with end-users) (see for instance Gravier *et al.* [15]) and/or comparison with existing vulnerability maps established with other methodological approaches. It is assumed that around nine meetings a year (follow up or working session) with local experts/ stakeholders are needed for this validation at the RBD scale. Some interviewees mentioned the lack of procedure to carry out this step of validation.

- Scale recommended for the use of IDPR is closely linked to the scale of input data: given that the MNT is available at 1/50,000, that the hydrology data is available at 1/50,000, it is assumed that the relevant scale for the use of IDPR results is 1/100,000 [15]. According to local experts in general, groundwater vulnerability maps obtained through IDPR should not be used for decision making at local level (design of protective areas for drinking water production for instance). For a comparison between alternatives A and B, it is likely that probabilities of taking the right decision (P_1 and P_4) at local level will be lesser than with the use of vulnerability maps built with local expertise.

A.7.1.4 CBA Calculation

Costs

From *(5)*: $$C_{IDPR}^{R_j} = C_{(with)}^{R_j} - C_{(without)}^{R_j}$$

- *Alternative A:* The full cost of IDPR implementation for groundwater vulnerability assessment should be assessed. Cost for the development at RBD scale is around 30,000 €. IGN data acquisition was done at the national scale. According to IGN web site[8]: cost for MNT[9] is 81,000€ at the national scale (retail price: 0,60€/km²), cost for hydrography[10] is 99,000€ at the national scale (retail price: 1,50€/km²). It is assumed that the cost of one person-staff for one year is around 100,000€ [6]. Taking into account these assumptions, the total cost of vulnerability map application using IDPR for a 100,000 km² RBD is estimated at 124,000€ (no annual costs).

- *Alternative B:* The full cost of alternative tool for groundwater vulnerability assessment should be assessed. Cost for the development at RBD scale is around 150,000€. It is estimated that cost of required data is 4 times bigger and time needed for consultation is equal to the previous one. Taking into account these assumptions, the total cost of vulnerability map application using an alternative method (DRASTIC for instance) for a 100,000 km² RBD is estimated at 328,000€ (no annual costs).

- *Alternative C:* We assume that the cost of this alternative is equal to 0€.

[8] www.ign.fr
[9] BD ALTI ®
[10] BD CARTHAGE ®

Benefits

From *(2)*: $$B_{IDPR}^{R} = \sum_{ij} Y_{ij}^{R}$$

$$Y_{ij}^{R} = NB_{ij(with)}^{R} - NB_{ij(without)}^{R}$$

Let us set some assumptions to apply the methodological framework developed in §3.4:

Scenario	GW Vulnerability (not known)	Decision	Probability	Total discounted costs	Total discounted benefits	Total net discounted benefits
Alternative A	YES (0,5)	Action (0,95)	$p_1^A = 0{,}475$	M_{T_A}	E_{T_A+Z}	$E_{T_A+Z} - M_{T_A}$
		No action (0,05)	$p_2^A = 0{,}025$	E_{T_A+Z}		$-E_{T_A+Z}$
	NO (0,5)	Action (0,05)	$p_3^A = 0{,}025$	M_{T_A}		$-M_{T_A}$
		No action (0,95)	$p_4^A = 0{,}475$			
Alternative B	YES (0,5)	Action (1)	$p_1^B = 0{,}5$	M_{T_B}	E_{T_B+Z}	$E_{T_B+Z} - M_{T_B}$
		No action (0)	$p_2^B = 0$			
	NO (0,5)	Action (0)	$p_3^B = 0$			
		No action (1)	$p_4^B = 0{,}5$			
Alternative C	YES (0,5)	Action	$p_1^C = 0{,}5$	M_{T_C}	E_{T_C+Z}	$E_{T_{CB}+Z} - M_{T_C}$
		No action	$p_2^C = 0$			
	NO (0,5)	Action	$p_3^C = 0{,}5$	M_{T_C}		$-M_{T_C}$
		No action	$p_4^C = 0$			

Figure 4. Costs, benefits and probabilities related to each alternative/ decision

We still consider three possible alternatives to implement a programme of measures to improve groundwater quality. We assume that groundwater vulnerability is unknown (we consider that 50% of the groundwater studies is vulnerable). For alternative A and B, decision concerning the spatial design of the programme of measures is taken through the information brought by IDPR. Precision of this information is supposed to be better for alternative B than A (probability of taking wrong decision for alternative A is supposed to be 5%, no failure for alternative B).

We also assume that $T_A = T_B < T_C$. This leads to $M_{T_A} = M_{T_B} = M$ and $E_{T_{A+Z}} = E_{T_{B+Z}} = E$.

Considering that implementation of measures in alternative C is delayed in time and taking into account discounting, we assume that $E_{T_{C+Z}} = (1-\alpha)E$ with α <1 and $M_{T_C} = (1-\beta)M$ with β <1.

From *(11)*: $$NB_{i(x)} = \frac{p_1^x \cdot (B_1^x - C_1^x) + p_3^x \cdot (B_3^x - C_3^x)}{p_1^x + p_3^x} + \frac{p_2^x \cdot (B_2^x - C_2^x) + p_4^x \cdot (B_4^x - C_4^x)}{p_2^x + p_4^x}$$

Application of (11) with assumptions made in Figure 4 and described above leads to the following results:

Alternative A: $NB_{i(A)} = 0{,}9 \cdot E - 0{,}94 \cdot M$

Alternative B: $NB_{i(B)} = (1-\alpha) \cdot E - (1-\beta) \cdot M$

Alternative C: $NB_{i(C)} = 0{,}5 \cdot E - M$

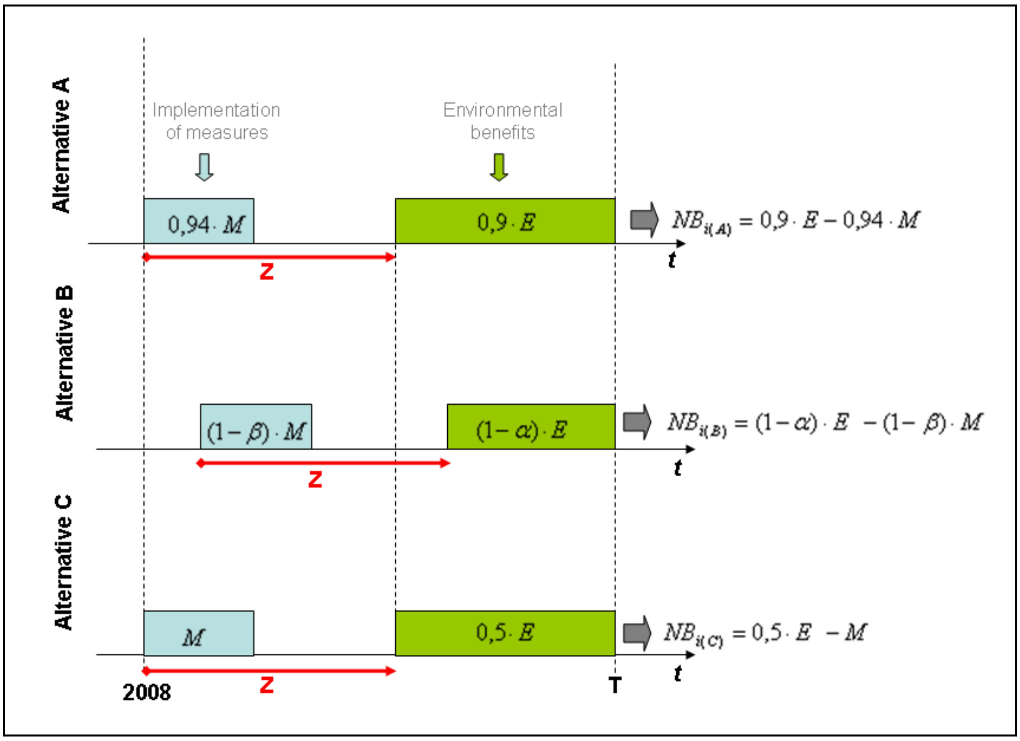

Figure 5. Costs and benefits related to each alternative

If the environmental benefits and costs related to the improvement of groundwater quality are known at a river basin district, it would then be possible to assess net benefits related to IDPR for the implementation of the programme of measures.

Ideally, it would be possible to make an exhaustive search for a large number of applications that had been improved with data from the national map pilot projects and determine the difference in net benefits of those applications thus recognized. Those observations would then be used to extrapolate the net benefits that could be reaped across the RBD. Those benefits would be weighted against the costs of developing the IDPR and a net benefit would be estimated (adapted from [7]).

Net Benefit at the RBD level

For each RBD, costs and benefits can be assessed as it is described above. Costs are quite easy to assess for one RBD and to extrapolate at other RBDs. On the contrary, benefits will be specific to each RBD as they can be expressed as a function of costs and benefits related to groundwater quality improvement.

From *(2)*:

$$NB_{IDPR}^{R_j} = f(E^{R_j}, M^{R_j}) - C_{IDPR}^{R} \qquad (12)$$

A.7.3 Analysis of the harmonisation at the National scale

A.7.3.1 Overview: End users, data providers, potential applications

In France (2007): The French Ministry for environment and sustainable development (MEDD) is the main end-user of the harmonisation of IDPR at the national level. The main data provider is IGN for MNT and hydrology. The main reason for harmonisation is to facilitate the implementation of WFD requirements (e.g. assessment of representativeness of monitoring network, assessment of the chemical status of groundwater bodies).

In Slovenia (2002): The main end-user was the Environmental Agency of the Republic of Slovenia, Geological Survey of Slovenia. The IDPR was used for assessing groundwater vulnerability and to help in the ground water bodies delineation. It was also recalculated and used in some other specific studies.

A.7.3.2 Advantages

⇨ Less time will be necessary to check the homogeneity of the various river basins data before sending it to the European Commission (costs/ time savings).

A.7.3.3 Disadvantages

⇨ No disadvantages have been quoted.

A.7.3.4 What does it mean in terms of cost benefit analysis?

❖ *Cost*

From *(5):* $C_H^{N_k} = C_{H(with)}^{N_k} - C_{H(without)}^{N_k}$

Alternative A: It is estimated that costs relies essentially on the production of a map and explanatory leaflet. The cost is estimated at 15,000 €.
Alternative B: No available data
Alternative C: No harmonisation (no method). Cost is equal to 0€.

❖ *Benefits*

Alternative A: Time savings for the reporting at the EU scale.
Alternative B: No available data
Alternative C: No harmonisation (no method).

A.8. Conclusions

From *(7):* $NB_{IDPR}^{France} = \sum_{R_j \in France} NB_{IDPR}^{R_j} + NB_H^{France}$

From *(12):* $NB_{IDPR}^{France} = \sum_{R_j \in France} \left(f(E^{R_j}, M^{R_j}) - C_{IDPR}^{R} \right) + NB_H^{France}$