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Understanding roles and information needs of stakeholders dealing with risk-based and sustainable brownfield regeneration: development of an Information System for the provision of customised solutions.

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Tesi di Dottorato di Erika Rizzo, matricola 813932

Coordinatore del Dottorato
Prof. Gabriele Capodaglio

Tutore del Dottorando
Dr. Andrea Critto

Co-tutore del Dottorando
Dr. Lisa Pizzol

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Summary

Presence of brownfields is a long standing, not yet solved, complex problem at international and EU level. Complexity derives from a combination of economic, environmental and social factors as well as interests, which make the regeneration decision-making process often difficult and slow. For long time, the most common approach to manage these areas was based on law prescriptions, cost-benefits calculations and, if needed, mitigation of unacceptable risks to human health and the environment. Only in recent years, it emerged that, in order to manage more effectively all economic, environmental and social aspects, sustainability principles as well as stakeholder involvement should be adopted. Furthermore, it has been recognised that information accessibility and customisation should be improved to enhance informed and therefore successful decision-making processes.

Accordingly, this Ph.D. thesis aims to set a background knowledge on risk-based and sustainable brownfield regeneration; to understand roles, perceptions, concerns, attitudes and information needs of EU stakeholders; and to develop an Information System for Brownfield Regeneration (ISBR) that allows to more deeply understand stakeholders' information needs and to answer them providing customised information to enhance informed brownfield regeneration among decision-makers.

As far as methods are concerned, stakeholder involvement has been adopted to understand and analyse stakeholders' roles, perceptions, concerns, attitudes and preliminary information needs. Based on this, the ISBR has been developed and has been tested to gain further feedbacks and to corroborate the first findings on information needs. Moreover, in order to make the tool able to tailor information to users who request them, an Artificial Neural Networks (ANNs) methodology has been developed and implemented. This ranking methodology is able to guess users' needs "learning" from the behaviour of similar previous ones.

The research work described in this thesis was carried out involving different groups of stakeholders from Czech Republic, Germany, Italy, Poland and Romania. It clarified which are the relevant stakeholders in brownfield regeneration and allowed to attain a partial cross-EU overview of their perceptions, attitudes, concerns and information needs. Also, it brought to deliver the ISBR that allowed to better understand stakeholders and to provide them with the needed information.

According to information gained during involvement activities, stakeholders' perceptions proved to be different in relation to the geographic context, while attitudes and concerns seemed to be similar between countries. As far as information needs are concerned, some similarities between some groups of stakeholders have been noticed: site owners and problem holders showed to be interested in information on planning and financing, while authorities and services providers are interested in investigation, planning and risk assessment. Quite unanticipated outcomes emerged from the scientific community and research group, which showed an interest for remediation strategies and options and socio-economic aspects. These findings allowed to create a knowledge base for the development of the ISBR.

From further engaging activities and from the analysis of data stored into the ISBR, a deeper understanding of stakeholders' information needs has been achieved. Overall, it was possible to identify a preeminent need for technical information on remediation as well as the need for benchmarking information and for information on relatively new issues like sustainability applied to brownfield regeneration and remediation.

Interesting insights emerged when information needs have been analysed considering the country where the information needed to be applied. It emerged that relatively new markets, from EU eastern countries, seek for information to support strategic planning and tools like geo-referenced inventories; while more mature

markets confirm a need for technical information on remediation. Also, from stakeholders' feedbacks, it appeared that the tool is actually designed to answer to stakeholders' needs.

This work discloses a set of possibilities for practitioners in brownfield management. Indeed, markets where they can apply their expertise to actually meet stakeholders' needs have been identified. This work can also offer guidance to other research areas where understanding stakeholders roles and needs is important for provision of customised information such as in complex decision-making processes like those related to renewables deployment and acceptance, or logistics management, or integrated coastal zone management.

Sommario

L'esistenza dei brownfield rappresenta ormai un problema di lungo periodo, non ancora risolto e di elevata complessità, sia a livello internazionale, che a livello europeo. Tale complessità deriva da una combinazione di fattori economici, ambientali e sociali come pure da una combinazione di interessi in gioco, che rendono il processo decisionale della riqualificazione ambientale spesso difficile e lento. Per lungo tempo, l'approccio più comune per la gestione di queste aree si è basato sull'osservanza di prescrizioni legali, sull'analisi costi-benefici e, quando necessario, sulla gestione del rischio per la salute umana e per l'ambiente. Solo di recente è emersa l'importanza di adottare i principi della sostenibilità nonché il coinvolgimento dei portatori di interesse (stakeholders), al fine di gestire più efficacemente i vari aspetti economici, ambientali e sociali. Inoltre, è stato riconosciuto che l'accessibilità alle informazioni, nonché la loro rispondenza a requisiti specifici dovrebbero essere incentivate e migliorate al fine di supportare processi decisionali informati e quindi efficaci.

Per approfondire questi aspetti, la tesi in esame mira a definire un background conoscitivo dei processi di riqualificazione basati sulla valutazione e gestione del rischio, sui principi della sostenibilità e sul coinvolgimento degli stakeholders. In riferimento a quest'ultimo aspetto, il lavoro mira a capire ruoli, percezioni, preoccupazioni, attitudini e bisogni informativi di stakeholders dell'UE, con l'obiettivo finale di sviluppare un "Information System for Brownfield Regeneration (ISBR)" (Sistema Informativo per la Rigenerazione dei Brownfield) che permetta di comprendere più approfonditamente i bisogni informativi degli utenti e che permetta di risolverli fornendo loro informazioni rispondenti a requisiti specifici al fine di incentivare un processo decisionale informato e quindi efficace.

Per quanto riguarda le metodologie utilizzate, è stato adottato il coinvolgimento degli stakeholders per capire e analizzare ruoli, percezioni, preoccupazioni, attitudini e bisogni informativi preliminari degli stessi. Sulla base di ciò è stato sviluppato e testato l'ISBR per raccogliere ulteriori informazioni e per approfondire e rafforzare i risultati iniziali relativi ai bisogni informativi. Inoltre, per rendere lo strumento capace di personalizzare le informazioni in funzione delle caratteristiche degli utenti, è stata sviluppata e implementata una metodologia basata sulle "Artificial Neural Networks (ANNs)" (Reti Neurali Artificiali). Questa metodologia per la classificazione delle informazioni è in grado di "ipotizzare" i bisogni degli utenti che usano lo strumento "imparando" dal comportamento di altri utenti, con caratteristiche e necessità simili, che lo hanno usato in precedenza.

Il lavoro di ricerca descritto in questa tesi è stato condotto coinvolgendo diversi gruppi di stakeholders provenienti da Repubblica Ceca, Germania, Italia, Polonia e Romania. Esso ha chiarito quali sono gli stakeholders nella riqualificazione dei brownfield e ha permesso di ottenere una visione delle percezioni, attitudini, preoccupazioni e bisogni informativi in una vasta area dell'Europa. Conformemente agli obiettivi, inoltre, il lavoro di ricerca ha portato allo sviluppo dell'ISBR che ha permesso di capire più approfonditamente gli stakeholders e di mettere a loro disposizione le informazioni di cui hanno bisogno.

Grazie alle attività di coinvolgimento sono stati identificati i ruoli, le percezioni, le preoccupazioni, le attitudini e i bisogni informativi preliminari degli stakeholders. Le percezioni si sono rivelate differenti da paese a paese, a differenza di attitudini e preoccupazioni che sono apparse simili nei vari paesi. Per quanto riguarda i bisogni informativi, sono state notate alcune somiglianze fra alcuni gruppi di stakeholders: proprietari di siti e "problem holders" (stakeholders che si fanno volontariamente carico di particolari problematiche legate alla rigenerazione dei brownfield) hanno mostrato il loro interesse per informazioni relative alla fase di pianificazione, anche finanziaria, mentre autorità e fornitori di servizi hanno mostrato interesse per

informazioni relative alle fasi di caratterizzazione, pianificazione e analisi di rischio. Risultati piuttosto inaspettati si sono avuti da parte della comunità scientifica che ha mostrato interesse per informazioni relative a opzioni e strategie di bonifica, nonché per informazioni relative ad aspetti socio-economici. Questi risultati preliminari hanno permesso di creare una base conoscitiva per lo sviluppo dell'ISBR.

Da ulteriori attività di coinvolgimento e dall'analisi dei dati memorizzati all'interno dell'ISBR, è stato possibile giungere a una comprensione più approfondita dei bisogni informativi degli stakeholders. In generale, è stato possibile identificare un prevalente bisogno di informazioni tecniche relative al tema bonifica, come pure informazioni di supporto all'analisi di casi di successo (benchmarking) e informazioni su tematiche relativamente nuove, quali quella della sostenibilità applicata alla riqualificazione ambientale e alla bonifica in senso stretto.

Particolari bisogni informativi sono emersi nel momento in cui questi sono stati analizzati considerando il paese nel quale l'informazione sarebbe stata applicata. Ciò che è emerso è che stakeholders di mercati dell'est Europa, relativamente giovani nel campo della riqualificazione ambientale, cercano informazioni che supportino la pianificazione strategica e strumenti quali inventari con funzionalità GIS, mentre mercati più maturi hanno confermato il loro interesse per informazioni tecniche di supporto alla bonifica. Inoltre, dai feedback ricevuti dagli stakeholders, è emerso che l'ISBR è considerato ben progettato e sviluppato per rispondere ai loro bisogni informativi.

Questo lavoro apre una serie di possibilità ai professionisti in campo di riqualificazione ambientale. Infatti, sono stati identificati mercati dove essi possono applicare le proprie competenze per rispondere ai bisogni informativi degli stakeholders. Inoltre, questo lavoro può esser di riferimento per altre aree di ricerca dove capire ruoli e bisogni degli stakeholders risulta importante per fornire informazioni personalizzate. Tali aree di ricerca potrebbero contemplare contesti dove i processi decisionali sono complessi, quali quelli relativi all'uso e all'accettazione delle energie rinnovabili, o quelli relativi alla gestione logistica di aree, o quelli relativi alla gestione costiera integrata.

List of contributions

Published papers and books:

- **Rizzo, E.**, Pesce, M., Pizzol, L., Alexandrescu, F., Giubilato, E., Critto, A., Marcomini, A., Bartke, S., 2015. Brownfield regeneration in Europe: Identifying stakeholder perceptions, concerns, attitudes and information needs. Land Use Policy 48, pp. 437–453.
- SuRF-Italy, RECONNET, 2014. Libro bianco 2014. Sostenibilità applicata alle bonifiche in Italia.

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- **Rizzo, E.**, Bardos, P., Pizzol, L., Critto, A., Giubilato, E., Marcomini, A., Comparison of international approaches to sustainable remediation.
- **Rizzo, E.**, Pizzol, L., Zabeo, A., Giubilato, E., Cosmo, L., Critto, A., Marcomini, A., Information System for Brownfield Regeneration: providing customised information according to stakeholders' characteristics and needs.
- Fisher, A., Darmendrail, D., Chiang, E., Mancini, K., Parker, M., Harclerode, M., Bardos, P., Nathanail, P., Risdale, R., Paquin, V., Alexandrescu, F., Pizzol, L., **Rizzo, E.**, Critto, A., Albano, A., SURF social white paper.

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- **Rizzo, E.**, Pizzol, L., Giubilato, E., Pesce, M., Zabeo, A., Critto, A., Marcomini A., 2014. Timbre Information System for the provision of tailored and customized information on brownfield regeneration according to users' requirements. In: Proceedings of CABERNET 2014 Conference: Tailored & Sustainable Redevelopment towards Zero Brownfields, Session: Solutions to bring state-of-the-art knowledge and information into application, Frankfurt, Germany (Retrieved 08.15) http://www.zerobrownfields.eu/HombreTrainingGallery/CABERNET%202014_PROCEEDINGS_o_LoP.pdf

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CHAPTER 1 Motivations, objectives, thesis structure and TIMBRE project

1.1. Motivations and objectives

De-industrialisation and economic change have produced many brownfield areas all over Europe. Brownfields can be defined as “sites that have been affected by the former uses of the site and the surrounding land; are derelict or underused; have real or perceived contamination problems; are mainly in developed urban areas; require intervention to bring them back to beneficial use” (CLARINET, 2002; CABERNET, 2006).

Both brownfield regeneration and remediation represent major concerns at European policy level. The European Environmental Agency (EEA) has estimated, only in 2013, that there are three million brownfields in the European Union (European Commission, 2013).

Land contamination, by industrial activities emissions, mining and smelting practices, agricultural chemicals or improper disposal of waste, affects large areas across the European Union (EU) as well. It is estimated that 2.5 million sites are potentially contaminated across Europe (Van Liedekerke et al., 2014). Another data proving the magnitude of problem of land contamination refers to the EU market for remediation of soil and groundwater, which in 2004 was estimated to be €5.2 billion (Ernst and Young, 2006). However, these data are highly uncertain and could underestimate the problems posed by of abandonment and contamination of land.

Therefore, several European policies and regulations have been enacted to deal with aspects related to contaminated sites and brownfield management. The Framework for Action for Sustainable Urban Development encourages brownfield regeneration and proves the EU concern for this problem (European Commission, 1998). Several directives, dealing with waste, water, industrial pollution prevention, chemicals, pesticides and nature protection, aim to achieve environmental goals related to soil protection as well. Among these policies, the Environmental Liability Directive (Directive 2004/35/CE), based on the "polluter-pays" principle, provides a legislative framework to prevent and remedy environmental damage.

However, since these directives have other specific aims than to ensure proper management and protection of land, a Soil Thematic Strategy (STS) was proposed by the European Community’s 6th Environment Action Programme. This implied the adoption of the Risk-Based Land Management (RBLM) framework (Vegter et al., 2002) and a proposal for a Soil Framework Directive (SFD) (European Commission, 2006). The RBLM framework embodies three crucial principles to achieve sustainable management of contaminated land: fitness for use (i.e., safe use or reuse of the land, managing risks and ensuring they achieve acceptable levels), protection of the environment (i.e., prevention and reduction of negative impacts on natural resources as well as conservation and improvement of their quality/quantity), and long-term care (i.e., solutions adopted should be appropriate according to a long-term vision).

The SFD was proposed to fill the gap of soil protection policy in the EU environmental legislation and to promote a common and holistic approach to land management. Nevertheless, the process for the SFD approval has been controversial to the point that the proposed directive has been withdrawn in 2014 and the adoption of an amended version is under discussion. This is due to the fact that member states consider that soil protection should be addressed nationally, taking into consideration local and site-specific needs as well as socio-economic structures. However, SFD underpinning principles are widely accepted by member states that enact and implement national policies accordingly. These policies indeed embody the RBLM

approach, meaning that human health risk assessment is recognised to be crucial in order to guarantee the appropriate management of contaminated soils and brownfields.

In order to effectively implement EU risk-based policies and recommendations within the different and also recently annexed EU member states, risk-based strategies, methodologies and tools need to be made available to the organisations involved in the assessment and management of brownfield and contaminated sites. Although much progress has been done in recent years, there are still many countries in Europe that have to deal with brownfields and contaminated lands on a large scale and that need effective sharing of useful information.

Due to their complexity and heterogeneity, brownfields have adverse effects not only on the environment, but also on the economic and social health of a region (Alloway, 1995; CLARINET, 2002) compromising communities' and stakeholders' interests. This brings to consider that, when dealing with brownfields, the three pillars of sustainable development (environment, society and economy) should be considered, particularly when assessing the possible impacts and benefits of undertaking any process, including remediation (SuRF-UK, 2010). This is proved by the fact that a number of international projects, initiatives as well as regulatory entities and site owners are beginning to use sustainable principles during the regeneration and remedy selection process (SURF, 2009).

Projects, initiatives and forums developing sustainable approaches to brownfield regeneration and remediation encourage considering, as well as the three pillars of sustainability, effective stakeholder involvement, since this is considered a key requirement for the optimal application of sustainability to regeneration and remediation.

Already the "Bellagio Principles" (as modified by Pintér et al., 2012) recognised the importance of stakeholder broad participation to achieve sustainability objectives, through transparency and effective communication. Transparency (Principle 5) guarantees disclosure of assumptions, uncertainties and choices making them accessible to all interested parties; effective communication (Principle 6) aims to present information in a fair and objective way that supports building trust among decision-makers and groups of interest; broad participation (Principle 7) implies that all stakeholder groups are addressed in order to increase legitimacy of the decision-making process.

In this research field, participation of all stakeholder categories is recognised to be a crucial prerequisite towards improving the acceptance and legitimacy of the regeneration decision-making process (Cundy et al., 2013; REVIT, 2007b; RESCUE, 2005). A notable example is the REVIT project (Revitalising Industrial Sites, 2007a), which encouraged stakeholder involvement, public discussion and local participation in some European cities and urban areas affected by the presence of brownfields. These activities concluded in the definition of shared redevelopment strategies, stimulated inhabitants to participate in the planning and in the execution of projects, enhanced effective communication and built the needed relationships with future generations (REVIT, 2007a).

Another requisite to achieve successful regeneration of brownfields is the availability of information to support informed and therefore effective decision-making processes. In the last decades, many EU research projects and initiatives developed a wealth of information, strategies, guidelines, tools as well as case studies to support effective brownfield regeneration. Nevertheless, this wealth of products had and still has a limited practical impact on brownfield revitalisation success, because they are too often not used in their entire potential due to their scarce visibility (Bartke et al., 2013). Therefore, stakeholders responsible for brownfield

regeneration are not always aware of the possibility to apply such useful, innovative and already available approaches and tools.

Already in 2006, CABERNET network recognised the importance of visibility and availability of useful information for successful brownfield regeneration since in all the process phases, decisions need to be informed and therefore based on up-to date, specific and customised information (CABERNET, 2006; Cianflone and Di Marco, 2007). The non-visibility of many of the developed approaches, methodologies and tools for brownfield regeneration hampers stakeholders in accessing useful information and is therefore recognised to be a problem.

In addition to the non-visibility of information, stakeholders face difficulties when searching for customised and site-specific information. These difficulties to access tailored information represent barriers to informed decision-making processes. Stakeholders' information needs can indeed be different, reflecting specific legal frameworks, local administrative and funding structures as well as site-specific requirements (Rizzo et al., 2013).

Consideration and integration of the above described issues, i.e. the importance of stakeholder involvement, and the importance of provision of information, which should be easily available to stakeholders and customisable to their needs, is considered to be beneficial to foster successful brownfield regeneration processes since it allows to identify all categories of stakeholders involved in the decisional process and to be sure that all of them have access to the information they need to clearly communicate with each other and to take informed decisions.

In order to enhance this, a partial EU-cross overview of stakeholders' roles, perceptions, concerns, attitudes and information needs when dealing with risk-based and sustainable brownfield regeneration will be provided in this research work.

It can be hypothesised that roles and categories of stakeholders, once identified, can be applied to different geographic contexts. While, it can be supposed that perceptions, concerns, attitudes and information needs can possibly change depending to the context where stakeholders act and to the categories they belong to. In particular, stakeholders from different contexts, which are usually characterised by different legal frameworks, financial structures, and progress in brownfield regeneration and remediation, could perceive problems differently and therefore could need different information to address these problems. As well, stakeholders belonging to different categories, may also need different information, suitable for the specific role they play.

In order to test this hypothesis, and to overcome the above mentioned barriers to informed decision-making in brownfield regeneration, the main aims of the Ph.D. project are:

1. To investigate the risk-based and sustainable brownfield regeneration process, and the related issues;
2. To identify roles and to understand perceptions, concerns, attitudes and information needs of stakeholders dealing with brownfield regeneration in the European context through engaging activities (workshops, focus groups and on-line questionnaires);
3. To develop an Information System for Brownfield Regeneration (ISBR) that, thanks to its Artificial Neural Networks, allows to more deeply understand stakeholders' information needs and to answer them providing customised information to finally enhance the sharing of useful information among decision-makers.

The ISBR is meant to be an on line platform for the tailored provision of relevant, innovative and widely applicable strategies, technologies and solutions for risk-based and sustainable brownfield regeneration. In particular, this tool aims to guarantee access to customised information to overcome informative barriers that could hamper stakeholders in achieving an informed dialogue and decision-making process.

1.2. Thesis structure

The thesis is structured in seven chapters, which present reasoning of the Ph.D. work, the theoretical background, the methodological developments, the applications and findings of the methodological developments and the conclusions.

CHAPTER 1 – "Motivations, objectives, thesis structure and TIMBRE project" introduces the rationale behind the conducted activities, presents the aims of the Ph.D. project and contextualises the thesis work.

CHAPTER 2 – "Risk-based sustainable brownfield regeneration, sustainable remediation, and available approaches for information provision".

This chapter presents background on risk-based and sustainable brownfield regeneration, and related concepts (e.g. contaminated sites, sustainable remediation, greenfields), brownfields regulatory environment in Europe, the European projects and research initiatives on brownfield management, the concept of sustainable remediation, the role of stakeholders in sustainable brownfield regeneration and sustainable remediation. A comparison between sustainable brownfield regeneration and sustainable remediation is also provided.

Moreover, this chapter presents a background on available approaches for information provision. In particular, information systems and information platforms already available will be presented, and the Artificial Neural Networks approach will be introduced.

CHAPTER 3 – "Brownfield regeneration and stakeholder involvement: a methodology to identify cross-European stakeholders' roles, perceptions, concerns, attitudes and preliminary information needs".

This chapter presents the participatory methodology applied to stakeholders from five European countries (Czech Republic, Germany, Italy, Poland and Romania) to identify stakeholders' categories, and to understand their perceptions, concerns, attitudes and information needs. The engaging activities supported the development of a *system of information categories for brownfield regeneration* for the categorisation of the needed information. Stakeholder involvement activities brought also to understand which typologies of information are the most relevant for specific categories of stakeholders, also in relation with their concerns.

CHAPTER 4 – "Development of an Information System for Brownfield Regeneration as web-based information platform to provide solutions according to stakeholders' characteristics and information needs".

This chapter presents, from a methodological point of view, how the ISBR has been developed. Therefore, the structure of the tool is depicted and described as well as the integration of the web database and the Artificial Neural Network-based ranking methodology.

Within chapter 4, methodological information on the further engaging activities conducted to test the tool during four workshops, held in Berlin (Germany), Brno (Czech Republic), Bucharest (Romania) and Katowice (Poland), will be provided.

Results and discussion of the research activities are presented in the following chapters:

CHAPTER 5 – “Identification of stakeholder categories, perceptions, concerns, attitudes and information needs in five European countries”.

This chapter presents and discusses results in terms stakeholders’ roles as well as perceptions, concerns, attitudes and information needs. Results have been obtained from the engaging activities that involved stakeholders from Czech Republic, Germany, Italy, Poland and Romania.

CHAPTER 6 – “Information System for Brownfield Regeneration: from the identification of stakeholders’ information needs and functional requirements to the provision of customised outputs”.

This chapter presents and discuss evidences that the ISBR is designed to allow to understand stakeholders’ information needs and to answer them. Moreover, it describes how the tool has been improved according to users’ requirements.

CHAPTER 7 – “Conclusions”.

This chapter includes considerations about the developed activities and main findings. It also highlights potentiality for further research in the field of risk-based sustainable brownfield regeneration and sustainable remediation.

1.3. TIMBRE project

The work presented in this Ph.D. thesis has been developed within the European project “TIMBRE” (www.timbre-project.eu/) started in 2011 and ended in June 2014.

The acronym TIMBRE stands for “Tailored Improvement of Brownfield Regeneration in Europe”. The project was funded by the European Commission (EC) within the 7th Framework Programme, under the theme “Environmental Technologies for Brownfield Regeneration”. TIMBRE project aimed at providing tailored and customised solutions to end users and, more in general, to stakeholders involved in brownfield regeneration processes.

TIMBRE project involved 15 European partners as well as an International Advisory Board (IAB) and was coordinated by the Helmholtz-Centre for Environmental Research - UFZ, Leipzig.

TIMBRE project focused in particular on the following objectives:

- Collecting, evaluating and classifying the bibliographical sources, programs, projects and accessible data that handled issues related to brownfield regeneration.
- Consolidating the technologies for brownfield regeneration based on evaluating the owner’s and decision factors’ necessities, and on the integrated approach of the problems and solutions.
- Identifying the obstacles due to specific socio-economic conditions in brownfield regeneration, based on an analysis on a local, regional and national scale of the administrative and law aspects.
- Developing and testing the tools for prioritization and classification of contaminated areas, depending on their remediation potential.
- Developing and testing the tools for evaluating and planning the remediation solutions.

- Improving the “in-situ” or “on-site” methods and technologies available on European level.
- Developing an on-line informational centre for brownfield regeneration.

The project was structured in 8 Work Packages (WPs):

WP1 aimed at developing an Information System as information platform for innovative and widely applicable strategies, technologies and solutions.

WP2 aimed at understanding decision structures and local culture as well as investigating the administrative possibilities and site-specific attitudes of stakeholders.

WP3 aimed at developing success metrics and a prioritisation tool for brownfield regeneration.

WP4 aimed at applying and assessing strategies and technologies for integrated site characterisation and remediation.

WP5 focused on deconstruction and re-use of structures and materials.

WP6 aimed at developing a web based tool for integrated planning and assessment of revitalisation options for brownfields.

WP7 aimed at providing a web platform, outreach, dissemination and transition, and WP8 focused on project management.

Some of the methodological developments and outcomes presented in this thesis were developed within the WP1 (leaded by the University Ca’ Foscari of Venice).

SECTION A – THEORETICAL BACKGROUND

CHAPTER 2 Risk-based sustainable brownfield regeneration, sustainable remediation and available approaches for information provision

2.1. Risk-based sustainable brownfield regeneration

2.1.1. Brownfields and related concepts and definitions

Brownfields are sites that have been affected by former uses of the site or surrounding land; are derelict or underused; are mainly in fully or partly developed urban areas; require intervention to bring them back to beneficial use; and may have real or perceived contamination problems (CABERNET, 2006). This definition is commonly agreed in Europe; however, this is not the only available and other international initiatives provide definitions of brownfields. SuRF-UK (2010) defines brownfield land as land that has been previously used, interchangeably termed "previously developed land", which may be contaminated as a result of previous uses. According to the US EPA (2011), the term brownfield site means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.

Often brownfields are referred as megasites when they are large in terms of area, regional impacts, complexity of contamination and of stakeholder presence (Agostini et al., 2007; Bardos, 2004).

This complexity implies that regeneration is often difficult and sustainability should be taken in proper consideration to manage all economic, environmental and social aspects.

In 2003, RESCUE project (Regeneration of European Sites in Cities and Urban Environments) introduces the concept of sustainability applied to brownfield regeneration and defines sustainable brownfield regeneration as "the management, the rehabilitation and return to beneficial use of the brownfield land resource base in such a manner as to ensure the attainment and continue satisfaction of human needs for present and future generations in environmentally non-degrading, economically viable, institutionally robust and social acceptable ways" (this definition is being taken forward by the EU FP7 project HOMBRE; GoT-HOMBRE, 2014).

In general, sustainable development is internationally agreed to be the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, 1987). It is represented as the overlap of the economic, environmental and social domains (*Figure 1*).

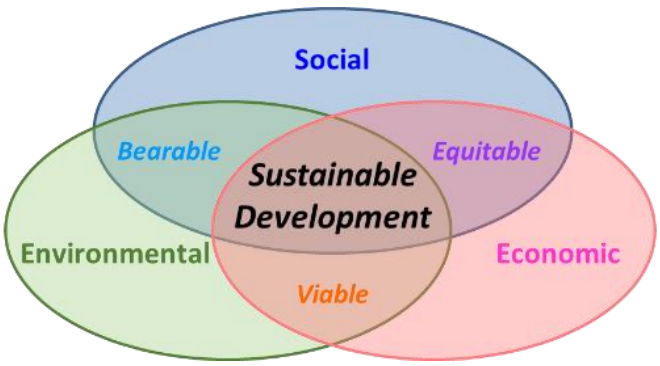

Figure 1 Sustainable Development.

ASTM (American Society for Testing and Materials) in 1984 defines the sustainable brownfields redevelopment process as "a voluntary effort that actively engages property owners, developers, government agencies and the community in conducting corrective action, economic evaluation, and other actions to promote the long-term productive reuse of a Brownfields property".

Williams and Dair in 2005 define sustainable brownfield development as a "development that has been produced in a sustainable way (e.g. in terms of design, construction and participation processes) and enables people and organisations involved in the end use of the site to act in a sustainable way".

Also the European Commission Framework for Action for Sustainable Urban Development demonstrates the EU long-standing concern for brownfield regeneration (European Commission, 1998), and CABERNET, in 2006, relates brownfield regeneration to sustainable urban development highlighting the importance of sustainability objectives setting.

Since brownfields, generally speaking, are potentially contaminated, other related concepts are remediation and *sustainable* remediation.

According to SuRF-UK (2010) remediation consists in those activities aimed at reducing or controlling the risks from all the relevant pollutant linkages associated with the site to a defined level, while sustainable remediation is defined as "the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process" (sustainable remediation will be elucidated in detail in Section 2.2).

Therefore, sustainable brownfield regeneration and sustainable remediation can be seen as overlapping domains in the wider context of sustainable urban development, as shown in Figure 2.

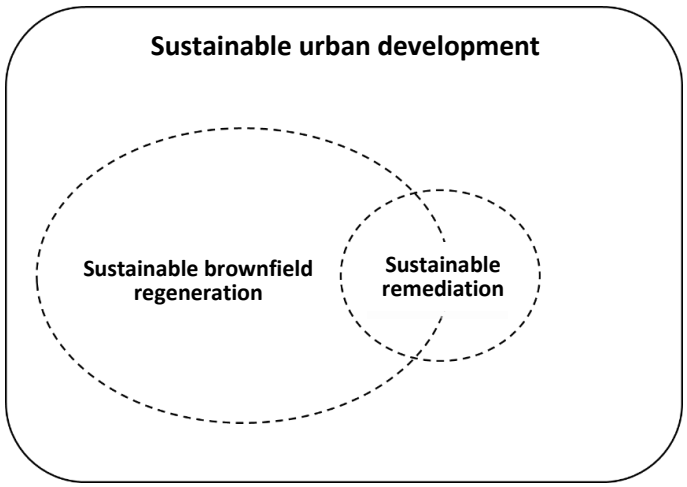

Figure 2 Sustainable urban development, sustainable brownfield regeneration and sustainable remediation.

Finally, another concept related to brownfields and contaminated sites is "green remediation" defined by US EPA in 2008. Green remediation is intended to reduce the demand placed on the environment during clean-up actions and to conserve natural resources. It anticipates that the major decision making elements setting the boundaries for remediation action, including economic and social considerations, have already taken place (US EPA, 2012). Hence green remediation is about improving the environmental performance of the delivery of the remediation solution after the point at which a remedial solution is selected (Bardos et al., 2013b).

2.1.2. Brownfield regulatory environment in Europe

In order to highlight the relevance of the issues discussed in this thesis and to show the complexity of the assessment and management processes that stakeholders and decision makers have to deal with and ask for specific support, the brownfield regulatory environment in EU has been investigated in the following paragraphs. At EU level, a wealth of directives, strategies and guidelines have been enacted to deal with aspects related to brownfield regeneration and remediation like waste, groundwater, urban environments, structural funds, resources efficiency, recycling, water, renewable energies, nature and habitats. Figure 3 illustrates how complex is this regulatory environment, while ANNEX I reports a table with policies and related references. Since member states adopt directives in accordance with the subsidiarity principle, it is possible to imagine how this complexity can be even amplified, if EU countries and related legislation are considered.

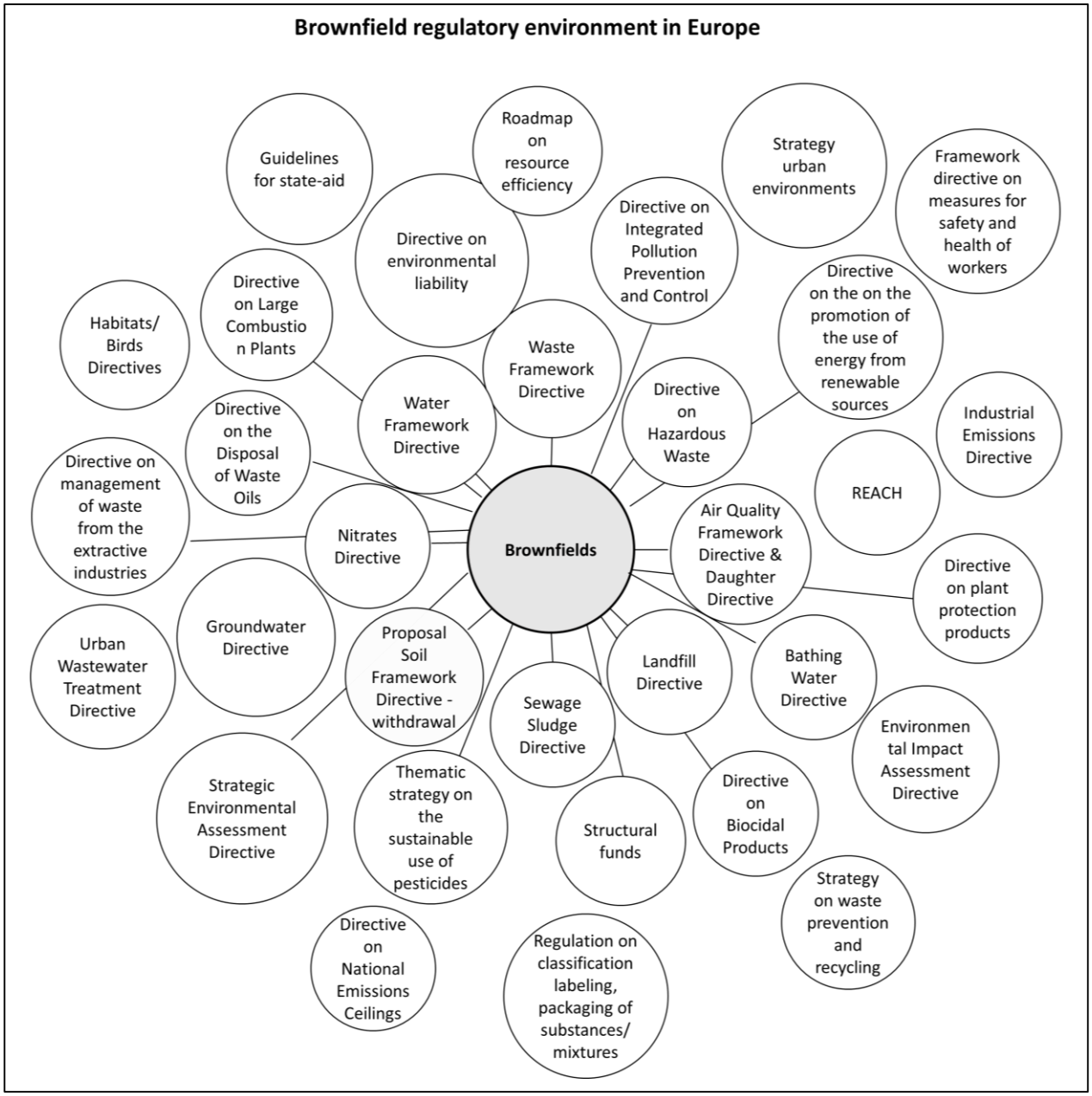

Figure 3 Brownfield regulatory environment in Europe (modified from Common Forum on Contaminated land, 2013).

It has to be highlighted that regulations depicted in Figure 3, even if provide indications on how to deal with some aspects related to brownfield regeneration, making the process quite complicate and oftentimes long in terms of time needed to answer to all prescriptions, have specific purposes which are not, strictly speaking, brownfield management.

As far as land management is concerned, a Soil Thematic Strategy (STS) was proposed by the European Community's 6th Environment Action Programme along with the Risk-Based Land Management framework (Vegter et al., 2002) and a proposal for a Soil Framework Directive (SFD) (European Commission, 2006). This policy, enshrining the risk-based land management concept, aimed at setting out common principles for protecting soils across the EU. Within this common framework, the EU Member States would have been in a position to decide how best to protect soil and how use it in a sustainable way on their own territory. Nevertheless, the SFD approval process has for long time been debated among member states, the proposed framework directive has been withdrawn in 2014, and the agreement on an amended version is still under discussion. However, SFD founding principles are widely accepted by member states that adopt and implement within their national policies the risk-based land management approach accordingly.

2.1.3. European projects and research initiatives on brownfield management

In the two last decades, different European projects and research initiatives on brownfield management and related issues have been funded. Table 1 presents objective and reference for each project/initiative reported.

Table 1 European projects and research initiatives dealing with brownfield management.

Project/Research initiative	**Objective**	**Reference**
ADVOCATE (Advancing Sustainable In Situ Remediation for Contaminated Land and Groundwater) Ongoing	As a Marie Curie Initial Training Network, ADVOCATE aims to provide advanced training to early stage and experienced researchers to develop innovative in situ remediation (ISR) concepts for the sustainable management of contaminated land and groundwater, as required by the Water Framework Directive.	http://www.theadvocateproject.eu/
CABERNET (Concerted Action on Brownfield and Economic Regeneration Network) 2002 – ongoing	To facilitate new practical solutions for urban brownfields.	CABERNET, 2006. Sustainable Brownfield Regeneration: CABERNET Network Report. ISBN 0-9547474-5-3. www.cabernet.org.uk/resourcefs/427.pdf
CLARINET (Contaminated Land Rehabilitation Network for Environmental Technologies) 1998 –2001	To identify the means for the effective and sustainable management of contaminated land and brownfields in order to: • ensure the safe (re-)use of these lands; • abate caused water pollution; • maintain the functionality of soil and (ground-)water ecosystems.	http://www.clarinet.at/
COBRAMAN (Manager Coordinating Brownfield Redevelopment Activities) 2008 –2011	To elaborate new concepts of brownfield management.	http://www.cobraman-ce.eu/Home/tabid/37/Default.aspx
EUGRIS (The European Groundwater and Contaminated Land Information System) 2002 – ongoing	To offer information and services on topics related to soil, water and brownfields. EUGRIS operates as a community of collaborating projects, people and organisations who co-operate to supply information for the benefit of everyone and also to promote themselves and disseminate their work.	http://www.eugris.info/index.asp

EURODEMO and EURODEMO + (European platform for demonstration of efficient soil and groundwater remediation) 2005 – 2012	To promote and encourage the use of soil and groundwater remediation technologies through demonstration, with emphasis on the use of sustainable and cost-effective remediation practices.	http://www.eurodemo.info/
GREENLAND (Gentle remediation of trace element contaminated land) 2011 – 2014	To enhance use of gentle remediation options.	http://www.greenland-project.eu/
HERACLES (Human Ecological Assessment for Contaminated Land in European Member States) (Available publication of 2007)	To promote the development of common references of site specific ecological risk assessment for contaminated land in Europe.	http://publications.jrc.ec.europa.eu/repository/handle/JRC32447
HOMBRE (Holistic Management of Brownfield Regeneration) 2011 - 2014	To create a paradigm shift to 'Zero Brownfields' where Brownfields become areas of opportunity that deliver useful services for society, instead of derelict areas that are considered useless. This ambition will be met by looking at how synergies between different types of services might leverage change where none was possible before.	http://www.zerobrownfields.eu/
NORISC (Network-Oriented Risk-assessment by In-Situ screening of Contaminated sites) 2001 - 2003	To combine and integrate new and existing investigation methods focusing on in-situ screening and on-site analysis in order to provide a standard guideline in the form of a decision support software system for efficient environmental assessment of contamination profiles in urban areas.	http://www.norisc.com/fabout.htm
REHMINE From 2010	The REHMINE research project, entitled "Contribution of Corporate Social Responsibility for Sustainable Development", aims to contribute to maximize the value generated by the rehabilitation of brownfields by developing a conceptual model of	http://pascal.iseg.utl.pt/~socius/rehmine/en/?Welcome

	decision support that integrates the interests of stakeholders, based on the principles of corporate social responsibility and sustainable development.	
RESCUE (Regeneration of European Sites in Cities and Urban Environments) 2002 – 2005	To provide guidance for the management of sustainable brownfield projects.	www.rescue-europe.com
REVIT (Towards more effective and sustainable brownfield revitalisation policies) 2004 – 2007	To generate a significant contribution to the increase of 'efficiency' and 'wider sustainability' of applied brownfield regeneration policies through transnational co-operation.	http://www.eugris.info/displayproject.asp?Projectid=4509
SAFIRA and SAFIRA II - Megasite Management System 2006 –2011	To provide an integrated framework that includes (i) a guideline assisting stakeholders in all stages of the revitalization process, (ii) a pool of state-of-the-art site investigation and remediation technologies, and (iii) a suite of software tools.	http://www.d-site.de/index.php/projects/ongoing-projects/21-safira-ii
SECOND CHANCE - From industrial use to creative impulse 2010 –2013	From Industrial Use to Creative Impulse – is more than a slogan. It is a vision of five European cities (Nuremberg, Leipzig, Venice, Krakow and Ljubljana) to transform a disused industrial site in a cultural and creative work and living space and to continue their revitalisation with sustainable concepts.	www.secondchanceproject.eu
SNOWMAN NETWORK Knowledge for sustainable soils Ongoing	To develop and share relevant knowledge for the sustainable use of soil and groundwater. For the development of relevant knowledge SNOWMAN has a research programme that it executes by organizing calls for projects. SNOWMAN shares the knowledge developed in these projects and the knowledge that is available among the members of the network.	http://snowmannetwork.com/
TIMBRE (Tailored Improvement of Brownfield Regeneration in Europe) 2011 – 2014	To support end-users in overcoming existing barriers on brownfield regeneration by having developed customised problem- and target-oriented packages of technologies, approaches and management tools for a megasite reuse planning and remediation.	http://www.timbre-project.eu/

2.2. Sustainable remediation

In the last decades, the most common approach to manage contaminated land has been based on the mitigation of unacceptable risks to human health and the environment. Only in recent years, several international initiatives have begun to apply sustainability principles to the management of contaminated sites and brownfields. Broadly speaking, sustainable remediation considers the environmental, social, and economic consequences of risk-management and clean-up activities themselves as well as the opportunities for wider benefit that sustainable land management strategies can offer beyond risk management (Bardos, 2014).

The application of the sustainable development principles to remediation is not a completely new idea (The Lower Swansea Valley project, 1961), with active consideration in Europe from the late 1990s/beginning 2000s (CLARINET, 2002; CABERNET, 2006). However, the first network specifically initiated with the aim of developing sustainable remediation was the Sustainable Remediation Forum of USA, SURF, established in 2006. Subsequent to SURF in the USA, similar forums have been established in the UK, in the Netherlands and in other countries with the aim of promoting sustainable remediation. Initiatives and European stakeholders' networks like Common Forum on Contaminated Land (hereafter Common Forum) and NICOLE (Network for Industrially Contaminated Land in Europe) have also made this an internationally recognised issue. A conference series specifically dedicated to this issue, SustRem, began in Copenhagen in 2009.

All these initiatives have developed documents like frameworks, guidelines, indicator sets and case studies to support practitioners in achieving sustainable remediation goals. These documents represent information that stakeholders dealing with brownfield regeneration and remediation could need to make their own process and work more equitable from an economic, environmental and social point of view.

Also, active stakeholder participation is considered fundamental for effective sustainable remediation (Common Forum and NICOLE, 2013). Accordingly, this participation has to be supported and enhanced by availability and sharing of customised information.

Several frameworks and steering documents on sustainable remediation (NICOLE, 2010; SuRF-Italy, 2014; SuRF-UK, 2010; SuRF-ANZ, 2011) contextualise sustainable remediation into sustainable brownfield regeneration, therefore some explanation of these contexts is necessary. Sustainable remediation and sustainable brownfield regeneration can be seen as overlapping domains in the wider context of sustainable urban development, as already shown in Figure 2.

Table 2 presents relations between sustainable remediation and sustainable brownfield regeneration. In the last column of the table it is possible to visualise if there is a total (T) or partial (P) overlap on how the two processes address the issues listed in the first column.

Table 2 Relations between sustainable remediation and sustainable brownfield regeneration.

	Sustainable remediation	**Sustainable brownfield regeneration**	**Overlap:** Total (T) Partial (P) None (N)
Addressed problem	Contamination.	Brownfield regeneration (or rehabilitation/redevelopment/development/requalification).	P
Definitions	Sustainable remediation: "the achievement of a net benefit overall across a range of environmental, economic and social concerns that are judged to be representative of sustainability" (Bardos, 2014).	Sustainable brownfields redevelopment process: "a voluntary effort that actively engages property owners, developers, government agencies and the community in conducting corrective action, economic evaluation, and other actions to promote the long-term productive reuse of a Brownfields property" (ASTM, 1984). Sustainable brownfield regeneration: "the management, rehabilitation and return to beneficial use of brownfields in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations in environmentally sensitive, economically viable, institutionally robust and socially acceptable ways within the particular regional context" (RESCUE, 2003). Sustainable brownfield development is a "development that has been produced in a sustainable way (e.g. in terms of design, construction and participation processes) and enables people and organisations involved in the end use of the site to act in a sustainable way" (Williams and Dair, 2005).	P
Contamination	Always.	Not always. Note: brownfields may include multiple contaminated sites.	P
Time frame	Short to long.	Short to long. More probably long, but if decision is made to act, regeneration can be quick.	P
Area	Small to large.	Tend to be large (hectares).	P
Stakeholders involved	1. Site owners 2. Site neighbours 3. Local authorities (town or city) 4. Region and sub-regional government 5. Regional and national regulators 6. Local community groups (neighbourhood, districts)	1. Site owners 2. Site neighbours 3. Local authorities (town or city) 4. Region and sub-regional government 5. Regional and national regulators 6. Local community groups (neighbourhood, districts)	T

	7. Public interest groups 8. Developers/investors 9. Technology providers 10. Consultants 11. Financiers 12. Contractors 13. Insurers 14. End-users 15. Media 16. Scientific community and research	7. Public interest groups 8. Developers/investors 9. Technology providers 10. Consultants 11. Financiers 12. Contractors 13. Insurers 14. End-users 15. Media 16. Scientific community and research	
Policy context	At international level, management of contaminated sites and remediation procedures are usually addressed by national and local legislative frameworks. Sustainable remediation has been only recently included in some national legislative frameworks, but usually with only general indications/suggestions. An exception is represented by Austria (Europe), where, since 2012, the application of the MCEA tool for sustainability options appraisal is mandatory when requesting resources from the Austrian National Remediation Fund.	Sustainable brownfield regeneration has been included in some national legislative frameworks and some documents provided by national environmental protection agencies, usually with general indications and suggestions. Nevertheless, several EU directives have been enacted to deal with some aspects related with brownfield regeneration (e.g. environmental liability, urban environments, structural funds, state-aids, resources efficiency, waste, water, groundwater, renewable energies, nature and habitats).	P

ANNEX II lists definitions and principles of sustainable remediation from around the world. Definitions show a high degree of consistency. Based on the exact wordings met in the definitions, a number of recurring themes can be identified. These themes can be explicitly or implicitly mentioned. For instance, the theme "Sustainability assessment/Assessment implied" is explicitly mentioned by Common Forum, NICOLE and ITRC, while it is implicitly meant by SuRF-Italy, SuRF-UK and SuRF-ANZ within the expression "balanced decision-making process", where "balanced" implies the concept of assessment.

However, typically definitions do not stand alone, but are supported by a number of broader principles in a supportive text (ANNEX II). Table 3 lists the initiatives and the themes that occur more than once across the wordings of definitions and principles. Themes are listed according to the number of times they are mentioned by the initiatives. Table 3 indicates in each cell if the theme reported within the wordings is met:

- in the definition (D);
- in the principles (P);
- in the definition and in the principles (D&P).

It has to be considered that almost all or even all themes could occur in all initiatives' documents; however, here, the analysis aims to specifically focus on the wordings used in definitions and principles. Therefore, if a cell is empty, it does not mean that that theme is not present at all in the document, but only that is not present in the definition and principles. Themes can be missing in some cell because initiatives wanted to focus on others, or probably because absent themes are taken for granted, or because they are mentioned in other parts of the document.

Table 3 Themes mentioned more than once in definitions and principles, and listed according to the times they are mentioned.

		THEMES																
		Benefit optimisation/Better remediation solutions	Human health/Environmental health/Risks - RBLM	Three pillars/elements of sustainability	Sustainability assessment/Assessment implied	Decision making process	Transparency	Stakeholders	Emphasis on technical environmental issues and	Long term vision	(Contaminated land) Management	Sound science	Use of indicators/metrics	Complying with regulations	Judicious limited resources use/use of resources	Record keeping	Safe working practices	Emphasis on socio-economic factors/community impacts
INITIATIVES	Common Forum	D&P	D	D	D	D&P	D		P	P	D				P			
	NICOLE	D&P	D&P	D	D	D&P	P	D&P	P	P	D		P		P			P
	SuRF-Italy	D	P	D	D	D&P	P	D&P			D	P				P	P	
	SuRF-UK	D	P	D	D	D&P	P	P				P	D			P	P	
	ITRC	P	P	D&P	D	P			P					P				P
	SuRF-Canada	D	D	D														
	SURF	D	D						P	P					D			
	SuRF-ANZ	D	P	D	D	D&P	P	P				P	D			P	P	
	ASTM	D			D				P		D		D	P				
	ISO	D	D&P	D		P	P	P		P		P		P				P
TOTAL		10	9	8	7	7	6	5	5	4	4	4	4	3	3	3	3	3

Interestingly, the theme “Benefit optimisation/Better remediation solutions” is mentioned by all initiatives in their definitions and principles.

The following four themes are mentioned in most (but not all) frameworks: the pre-eminence of risk assessment as the basis of deciding the need for remediation, the three sustainability pillars, and the balanced approach to the decision making process.

Looking across Table 3, the themes “Sustainability assessment/Assessment implied”, and “(Contaminated Land) Management” occur only in the definitions; while the following ones are met only in the principles: “Emphasis on technical environmental issues and actions”; “Long term vision”; “Sound science”; “Complying with regulations”; “Record keeping”; “Safe working practices”; “Emphasis on socio-economic factors/community impacts”. This can offer guidance to new initiatives on sustainable remediation to develop their definitions and guiding principles.

In addition, there are some unique points made in the definitions and principles of few frameworks only: the importance of communication, the bottom-up approach and the sharing of experiences through case studies for NICOLE; the consideration for both local and larger community level for SuRF-Canada; and the time issue for ISO.

NICOLE, besides the principles shared with Common Forum (Common Forum and NICOLE, 2013) to contribute to long-term sustainable development, states also additional key principles that show a high concern for building trust between stakeholders and for considering socio-economic factors in sustainable remediation.

SuRF-Italy refers directly to the six SuRF-UK principles, which are in line with the ones shared by Common Forum and NICOLE, and which are also related with some technical considerations (e.g. safe working practices for workers and local communities, record keeping and transparent reporting).

ITRC, SURF and ASTM principles show an explicit concern for environmental issues, activities and consequent impacts that can occur during a remediation process (e.g. energy consumption, release to the environment). This tendency could be explained by the fact that, in the USA, green remediation plays a big role in contaminated land management and has been strongly encouraged by the US EPA, which considers it “as the practice of considering all environmental effects of clean-up actions and incorporating options to minimize the environmental footprints of clean-up actions” (2011).

2.3. Stakeholder involvement in risk-based sustainable brownfield regeneration and sustainable remediation

The involvement of stakeholders in all phases of the regeneration process has been recognised as an important prerequisite towards improving the acceptance of the decision-making process (Cundy et al., 2013; REVIT, 2007b; RESCUE, 2005). Moreover, at the institutional level, the awareness of the importance of an effective stakeholder involvement lead to the promotion of public participation at brownfields and contaminated sites (Gallagher and Jackson, 2008), especially at local and site specific levels. A notable example is the REVIT project (Revitalising Industrial Sites, 2007a), which encouraged stakeholder involvement, public discussion and local participation in some European cities and urban areas affected by the presence of brownfields (Stuttgart in Germany, Nantes in France, Tilburg and Hengelo in the Netherlands, Medway and Torfaen in the United Kingdom). These activities concluded

in the definition of shared redevelopment strategies, stimulated inhabitants to participate in the planning and in the execution of projects, enhanced effective communication and built the needed relationships with future generations (Revitalising Industrial Sites, 2007a).

Effective stakeholder involvement has recently been adopted also to deal with contamination perception, assessment and management at brownfield sites. A remarkable example is SuRF-UK (United Kingdom's Sustainable Remediation Forum) that promotes stakeholder engagement for sustainability assessment of remediation options in order to identify the best remediation technologies and to properly communicate with stakeholders the decisions on remediation processes (SuRF-UK, 2013). Sparrevik et al. (2011) present a study, where stakeholders were involved in order to collect and evaluate factors affecting their "risk perception of contaminated sediment disposal that occurred during a remediation project in Oslo harbor, Norway". Cundy et al. (2013) described the importance of stakeholder engagement when implementing green versus other remediation options at contaminated sites. The above described examples clearly demonstrate the importance of stakeholder involvement, nonetheless, it has to be considered that stakeholder engagement is only one of multiple factors for success in brownfield regeneration decision-making processes.

However, considering the engaging activities described above, they were mainly devoted to collect stakeholders' feedbacks on specific technological or local concerns (e.g. disposal of contaminated sediments, identification of suitable remediation options, definition of a shared redevelopment strategy) related to the presence of brownfield sites located in the surrounding areas of the involved communities.

Conversely, this work involved stakeholders to provide an overview of their roles, perceptions, concerns, attitudes and information needs when dealing with brownfield regeneration. In particular, in Chapter 3, a participatory methodology for collecting and analysing roles, perceptions, concerns, attitudes and information needs of stakeholders from Czech Republic, Germany, Italy, Poland and Romania is presented.

2.4. Information systems, information platforms, and potentialities of the Artificial Neural Networks approach

Information systems and information platforms are software and hardware systems that support data-intensive applications. These tools are based on computerised set of procedures that, when executed, provide information to support processes, decision-making and control in the organisation (Lucas, 1990).

At international level, some information systems and platforms for brownfields and contaminated land management and related issues have been developed. In the following, some examples are reported:

- United Nations Environment Programme "Global Partnership on Waste Management" Information Platform (UNEP GPWM Information Platform).
  This tool is an information platform to support proper waste management, collecting and sharing information to strengthen local, national and regional decision-making processes

related to waste management. The UNEP GPWM Information Platform is an online platform that aims to promote, share and exchange information on solid waste related issues.

- United States Environmental Protection Agency "Superfund Site Information" (2011) contains general information on sites across the U.S. territories including location, contaminants and clean-up actions taken. The tool supports in finding information on sites being assessed under the Superfund program. National Priorities List (NPL) sites are systematically described as well. All information is presented in non-technical user-friendly language.
- US EPA Contaminated Site Clean-Up Information (CLU-IN) is a web site that provides information about innovative treatment and site characterisation technologies to the remediation community. It describes programs, organisations, publications, and other tools for federal and state personnel, consultants, technology providers, remediation contractors, academia and individuals with remediation concerns. The site is intended as a forum for all interested stakeholders.

In EU, an example of portal for practitioners dealing with soil issues is the European Soil Data Centre (ESDAC), which represents a soil data infrastructure for research and policy making. This free and on-line tool has been developed by the European Commission Joint Research Centre (JRC) with the aim of providing policy relevant soil data and information to Commission services and external customers. ESDAC integrates and hosts soil data from EU Member States and neighbouring countries. It covers the complete data production cycle, from raw data collection to the final integrated assessment of European soil resources. It also allows linking to data and information from National providers, fully complying with the interoperability principle. Furthermore, ESDAC is as "open" as legally possible, meaning that if data and information resident in the ESDAC can legally be published, the system will do. Finally, ESDAC provides web mapping services.

Also, at EU level, EUGRIS, the portal for soil and water management in Europe, makes available pre-eminent sources of technical, policy and research information in contaminated land and brownfields across Europe. The EUGRIS portal integrates a technical and policy collection of information with a search engine and a dissemination tool. It offers links to sources of information and allows registered users to share their own information as well. EUGRIS is an open system that provides information to properly manage contaminated land, soil, water and groundwater. It allows user-friendly access to information according to specific users' needs. Most of the information collected in EUGRIS is meta-data (i.e. information about the information, rather than the information itself, which is stored on the source website) (P. Bardos et al., 2009). Summing up, EUGRIS primarily goal is to foster exchange of information on soil and water management among stakeholders in a user-friendly way.

Considering the information systems described above and the related purposes, the ISBR developed during the thesis work shares with them the aim of improving exchange of useful information on brownfield regeneration among users. Additionally, the ISBR allows understanding brownfield stakeholders' characteristics and information needs in order to provide them with the most customised information on brownfield management, as described in CHAPTER 4 **Development of an Information System for Brownfield Regeneration as web-based information platform to provide solutions according to stakeholders' characteristics and information needs** and CHAPTER 6 **Information System for Brownfield Regeneration: from the identification of stakeholders' information needs and functional requirements to the provision of customised outputs**.

The main idea behind the proposed ISBR was to develop a tool able to tailor search results to the characteristics and needs of users who requests them. As, in general, there is no a priori knowledge about users, there was the need for a ranking methodology able to guess users' needs from the behaviour of similar previous ones. The solution to this ranking problem appeared to be the use of Artificial Neural Networks (ANNs) (Mehrotra et al., 1997).

ANNs refer to computing systems that present analogies with biological neural networks. The neural network of an animal is part of its nervous system, containing a large number of interconnected neurons (nerve cells). In ANNs, "neural" is an adjective for neuron, and "network" denotes a graph-like structure. An ANNs-based computing system is composed by a graph structure where nodes (neurons) perform calculations and connections transfer signals from one node to another.

ANNs approach presents strong potentialities for developing information systems, because it allows to deal with "many-input many-output" problems, issues, situations or conditions, which need to be well understood and properly managed. Problems that ANNs can deal with are represented, for instance, by problems in automatic control (e.g. the performance of a gantry crane that needs to be understood and manipulated), or by financial forecasting problems, where predicting values of prices of products in different cities is vital for right investments (Mehrotra et al., 1997).

SECTION B – METHODOLOGICAL DEVELOPMENT

CHAPTER 3 Brownfield regeneration and stakeholder involvement: a methodology to identify cross-European stakeholders' roles, perceptions, concerns, attitudes and preliminary information needs

In the following, the methodology adopted for the identification of roles, perceptions, concerns, attitudes and preliminary information needs of stakeholders involved in the brownfield regeneration process is elucidated.

The proposed methodology consists of five phases: 1) planning and preparatory work; (2) stakeholder identification and selection; (3) workshops and focus groups; (4) web-based questionnaire; and (5) feedbacks to stakeholders. The main results expected from the methodology will be derived from the second, third and fourth phases of the engagement process. More exactly, the second phase will help to develop a comprehensive list of stakeholders potentially involved in brownfield regeneration. As part of the third and fourth steps, the stakeholders' profiles will be identified, along with their perceptions, concerns and attitudes on brownfield regeneration. Within these steps, the focus will also be on recognising information needs and highlighting which are the most important, useful and critical for specific categories of stakeholders and in relation with the identified concerns. The final result achieved within these two phases will be to classify the collected information needs within a categorisation system for the collection of information on brownfield regeneration. The above mentioned methodological phases are illustrated in Figure 4, along with the expected results, which are reported as rectangles. The specific motivations and characterisations for the suggested phases are discussed in the following sub-sections.

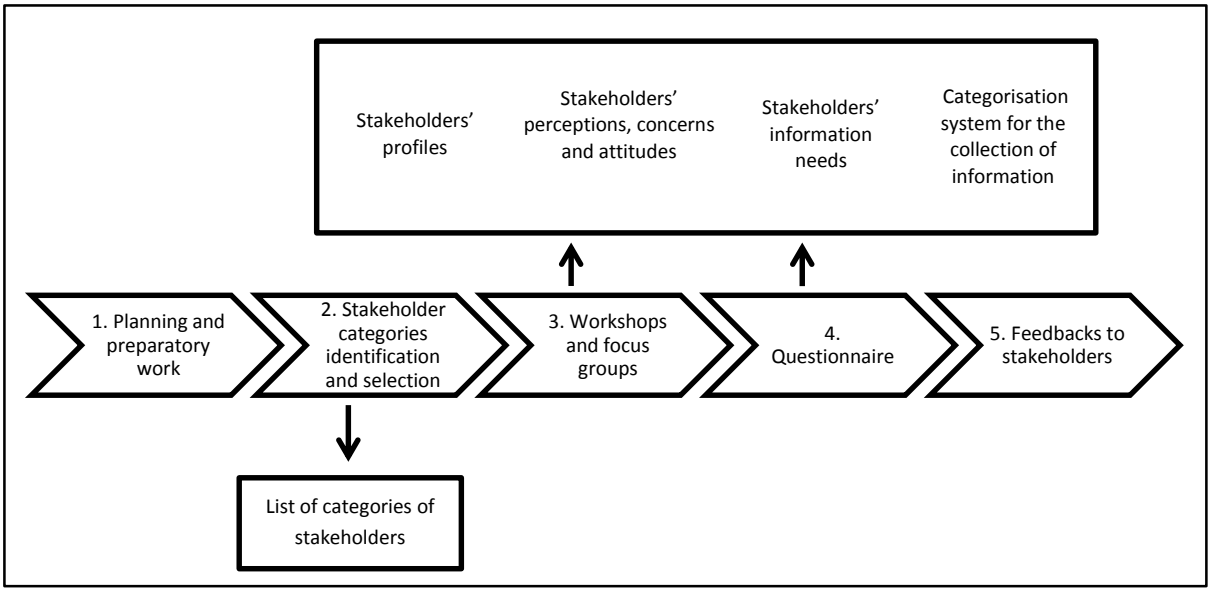

Figure 4 Stakeholder engagement process for the systematic collection of perceptions, concerns, attitudes and information needs.

3.1. Planning and preparatory work

It has been considered that stakeholders as well as researchers are likely to gain from an engagement process (Rounsevell et al., 2012). Stakeholders can gain extra knowledge about their role within the

brownfield regeneration process and their relations with other stakeholders. Researchers can collect useful information necessary for the main aim of their study, and in particular information concerning stakeholders' perceptions, concerns, attitudes and information needs when dealing with brownfields, which is useful for the development of more tailored methodologies, approaches, tools and strategies in the field of brownfield regeneration. Researchers can then feed-back the outcomes of the engagement process to the stakeholders. Before discussing different forms of stakeholder engagement, the four concepts of perceptions, concerns, attitudes and information needs shall be explained. Stakeholder perceptions are the ways in which stakeholders describe and define a given problem, for example that of brownfields. Their concerns reflect more specifically the negative aspects of those perceptions. The attitudes of stakeholders reveal how important a given problem is for stakeholders, in relation to the things they value (e.g. health or economic costs). Finally, the information needs suggest the kinds of information that stakeholders say they would need in order to deal with a given problem, thus suggesting a proactive stance.

Enengel et al. (2012) differentiate among three forms of stakeholder engagement: a) information, b) consultation, and c) knowledge co-production and empowerment. The involvement of stakeholders with expertise in the field of brownfield regeneration was considered necessary for the achievement of the above listed objectives. The selected degree of engagement is the "consultation" level, consisting of gathering information from participants (Alexandrescu et al. 2014a, Rowe and Frewer, 2000). Two methods were adopted in order to engage stakeholders: meetings in the form of workshops and focus groups, and an online questionnaire. In fact, it is a common practice to use focus groups in combination with other methods (NOAA Coastal Services Center, 2009) and one of the most common pairings is to combine meetings (i.e. workshops or focus groups) with questionnaires (Morgan, 1996).

3.2. Stakeholder identification and selection

On the basis of the outcomes of the planning phase, the second phase is aimed at defining categories of stakeholders and at selecting participants able and willing to participate in focus groups and respond to a questionnaire (Reed, 2008). Defining the categories of stakeholders, and therefore the roles they play, relies on expert opinions, focus groups, interviews, literature reviews, or a combination of them (Reed, 2008). Once the categories have been defined, participants must be contacted and selected. This can be done by means of calls for participation in workshops, which aim to mobilise all stakeholders with an interest in brownfield regeneration, and snowball sampling, in which stakeholders contacted during workshops provide references to other potential research participants. One aspect that needs to be considered is the required expertise and knowledge (Glicken, 2000). Glicken, (2000) identifies three types of knowledge through which stakeholders can contribute to the engagement process: cognitive knowledge, based on technical knowledge and expertise; experiential knowledge, based on practical and professional experience; and value-based knowledge (socio-political knowledge), based on endorsement of social values.

In this study, key stakeholder roles and categories were identified through a close collaboration between the TIMBRE partners and the expert members of the project International Advisory Board (IAB). For the identified categories of stakeholders, TIMBRE researchers proposed to contact some representatives on the basis of the following characteristics:

- expertise in their field: it was agreed that knowledge and experience in the brownfield regeneration process were fundamental for the value of the engagement process, thus covering the first two types discussed above; and
- propensity to participate: another fundamental aspect to consider was the availability and willingness to participate in the engagement process.

3.3. Workshops and focus groups

As agreed in the planning phase, workshops and focus groups have been selected as the first operative phase of the engagement process. Workshops are meetings where stakeholders come together to find solutions to common problems (WHO, 1987). They have the aim to facilitate the flow of information from experts to researchers, thus having a primary informative rather than data-collection role. As such, they were considered appropriate for the initial stages of stakeholder engagement, in which stakeholders needed to be introduced to the problem and to the researchers and to each other.

Focus groups are a special type of setting used to gather information from a limited number of members of a clearly defined target audience. They are composed of six to twelve stakeholders who are similar in one or more aspects and are guided by a facilitator through a discussion focussing on several related topics in order to gather information about the opinions and expertise of group members in a comfortable environment (Rennekamp and Nall, 2004; Wilcher et al., 1999).

In the proposed methodology, workshops were used mostly to introduce the TIMBRE project and the related issues of concern to participants, to stimulate discussions about their perceptions, concerns, attitudes and information needs concerning brownfield regeneration, to establish a good relationship for the continuation of the study and to present a preliminary, initial structure of the categorisation system for the collection of information on brownfield regeneration, drafted by project partners and the International Advisory Board, which together represent already several stakeholder categories (e.g. national regulators, public interest groups, technology providers, consultants, end-users, scientific community and research). Within this scheme, the main phases of the risk-based regeneration process are identified and correspond to thirteen “information categories” (Rizzo et al., 2013). The proposed categorisation system was the result of an analysis of the available brownfield rehabilitation schemes and frameworks developed in previous programmes and projects on contaminated sites and brownfields (Sanja et al., 2000; NORISC, 2001 - 2003; RESCUE, 2005; CABERNET, 2006; Pizzol et al., 2009).

Workshops were organised at the Hunedoara TIMBRE project site in Romania, in which the regeneration process is in its incipient phases (– cf. Alexandrescu et al., 2014b), at the Szprotawa project site and in the regional capital Zielona Góra in Poland (Pizzol et al., 2012b).

Stakeholders were contacted through a formal written invitation. In order to avoid loss of information, meetings were held in the languages of the participating stakeholders. Before the involving activities, a facilitator was trained in order to create the right conditions to lead the meetings.

Workshops lasted for several hours and they were structured in two parts. During the first part, the facilitator and the researchers introduced to stakeholders the TIMBRE project and the related issues of concern to stimulate a discussion on possible perceptions, concerns and attitudes, as well as on the above mentioned categorisation system for the collection of the needed information on brownfield

regeneration (see Figure 5). In the second part of the meetings, stakeholders were asked to provide opinions, comments and suggestions about the proposed categorisation system.

Focus groups were used at a later stage in the research process, when respondents seemed to be reasonably familiar with handling information related to the different stages of the brownfield regeneration process, with the aim of discussing the categorisation system and collecting information on their perceptions, concerns, attitudes and information needs.

Focus groups were two hours long and involved a limited number of stakeholders having a broader experience in brownfield regeneration, such as those in Bucharest, Romania, and Ostrava, the Czech Republic. After a brief presentation of the system for the collection of information on brownfield regeneration, the participants were asked to convey and exchange their views on it in terms of its perceived usefulness for their information needs. As for the workshops, stakeholders were invited to write down comments on a poster displaying the information categories. The discussions between stakeholders were recorded, with their consent, transcribed and translated for later analysis.

Even though, for workshops and focus groups, the selection of interviewees and participants was from countries with relatively developed brownfield markets, it has to be noticed that, for the other involving activities described in the following sections, the selection of participants spanned also to more mature markets. The idea behind involving stakeholders from relatively developed brownfield markets reflects the need to enhance dialogue across EU countries with different levels of experience and transfer information, first understanding real needs.

3.4. Web-based questionnaire

After workshops and focus groups, the second operative phase consisted in the administration of an online questionnaire to stakeholders. A questionnaire is an individual form of engagement and it consists in a set of questions for obtaining information from respondents. It is a very convenient way of collecting information from a large number of people within a relatively short period of time (Ng, 2006). Questionnaires include two formats of questions (Dillman et al., 2009):

- Closed-ended questions: questions that limit the respondents with a defined list of possible choices from which they must choose the answer (e.g. yes-no, multiple choice, and Likert questions);
- Open-ended questions: questions that allow respondents to develop their own answers.

In this study, the questionnaire was adopted in order to confirm and extend the information collected during workshops and focus groups, and to highlight the differences in perceptions, concerns, attitudes and information needs between stakeholder categories.

Moreover the questionnaires supported: i) to achieve a shared and agreed categorisation system for the collection of information on brownfield regeneration by collecting stakeholders' opinions and suggestions on information categories and by identifying possible gaps; and ii) to identify the order of categories of information from the most relevant to the least relevant one for all information users as a whole as well as for different categories. (iii) The questionnaire also allowed the cross-examination of stakeholders' concerns and of their information needs.

The questionnaire was structured in three parts. In each of them a specific combination of open-ended and closed questions was used:

1. Stakeholders' profile: the participants were asked, via closed questions, about the stakeholder categories to which they belong, and about their main activities related to brownfield

regeneration. Given the factual nature of such questions, the closed format was deemed to be the most appropriate.

2. Brownfield perceptions, concerns and attitudes: this part of the questionnaire was used to capture the understanding of respondents about the presence and regeneration of brownfields. The first question was open-ended and asked about the respondent's experience-based description of a brownfield site (stakeholders' perceptions). The second question was closed and was devised to assess the degree of concern that respondents had with regard to ten possible problems generated by the presence of brownfield sites on a scale from 1 ("very low concern") to 5 ("very high concern"). The third question was also closed and asked respondents about the opportunity of brownfields regeneration under different scenarios (stakeholders' attitudes towards brownfields).
3. Stakeholders' information needs and categorisation of information: in the last part of the questionnaire, stakeholders were asked to evaluate and provide comments on a proposed categorisation system for the collection of information on brownfield regeneration (Figure 5). This preliminary structure was developed by the TIMBRE researchers with feedbacks from the workshops and focus groups. Most questions in this part of the questionnaire were closed, with the aim of assessing as precisely as possible the usability of the information structure according to different stakeholders' needs. For collecting descriptive feedbacks on stakeholders' choices of information categories, open-ended questions complemented the closed ones. Stakeholders were guided through the evaluation of the system with a series of instructions that asked them: a) to select the categories of information on brownfield regeneration fundamental for their work; and b) to rank the selected categories in order of importance, always referring to their objectives within the brownfield regeneration process (from 1, indicating the most relevant category, to n, indicating the n^{th} relevant category of information).

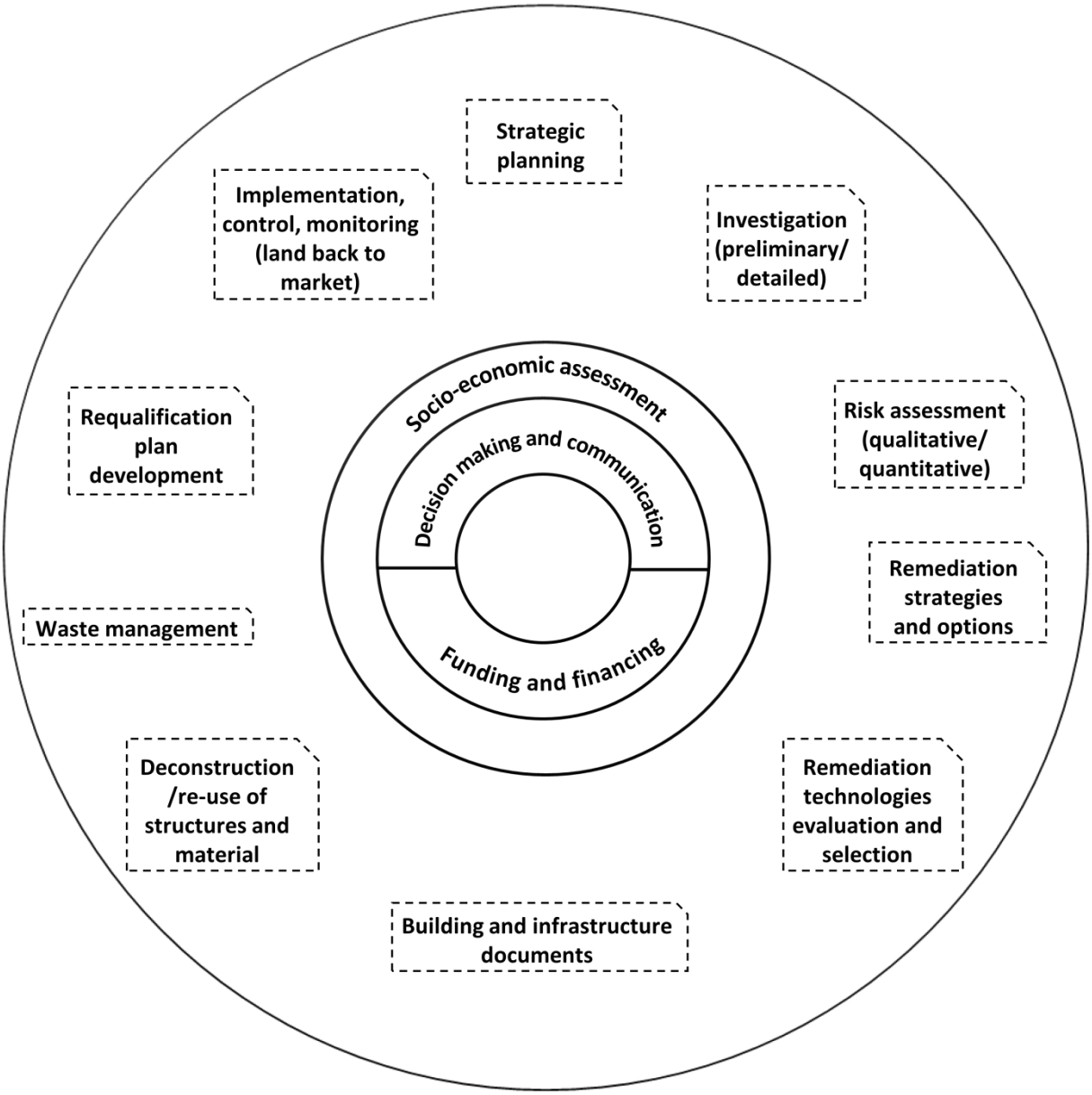

Figure 5 System of information categories for brownfield regeneration processes evaluated by experts-stakeholders (Rizzo et al., 2015).

In order to start understanding which type of information was considered more important by stakeholders, the rankings of the information categories, according to the relevance scores, have been elaborated according to the Kemeny-Young method (Kemeny, 1959; Kemeny and Snell, 1960; Young and Levenglick, 1978; Young, 1988). Kemeny-Young is a statistical method to analyse different rankings of elements and find the most frequently chosen ranking among them. The method considers all possible rankings provided by the respondents and gives a score to each of them. It is not mandatory for respondents to rank all the elements. Those categories that were not classified are interpreted as "least preferred" and they go to the bottom of the rank. The ranking with the highest score is the most agreed between all the respondents. The "winner" ranking might be one of those provided by the respondents, or a new, constructed ranking, which takes into account all the rankings provided by the respondents.

Once the questionnaire had been developed, it was pre-tested by sending it out to a limited number of stakeholders of the Romanian case study in order to detect possible errors or to identify possible

misunderstandings and doubts of the respondents. Often, questions may look clear to the researcher but not to the respondents. It is, therefore, good practice to “pilot” the questionnaire with a small sample of respondents before distributing it to all respondents. Any amendments highlighted by the pilot should be made to the questionnaire before issuing a final version (Kirklees, 2008).

The questionnaire was then translated in the five languages of the case studies and then submitted to the stakeholders through the internet. The online format was chosen because the questionnaire could be easily filled directly in a webpage without the need to print it or send it back by e-mail, and because the data were automatically saved upon completion in a dedicated database. It was considered necessary to contact a minimum number of 30 stakeholders from every country, in order to obtain a sufficient number of responses. Out of 182 questionnaires sent, a total of 55 (30%) were returned. Different numbers of stakeholders were contacted in the five countries and the final response rate for each country was: Czech Republic 32%; Germany 52%; Italy 22%; Poland 18%; and Romania 36%.

3.5. Feedbacks to stakeholders

The last phase of a stakeholder engagement process usually consists in collecting and evaluating results, and then providing feedbacks to the stakeholders that participated in the process. Qualitative data resulting from meetings (workshops and focus groups) were obtained from audio/video records realised during the events, transcribed into a word processing software, translated in English by project partners and then directly analysed. Quantitative and qualitative data resulting from the web-based questionnaire were collected and then analysed using descriptive statistics and visually represented through graphs and charts in order to summarise the answers of respondents on specific questions. Feedbacks to stakeholders have then been provided both through the provision of project deliverables, which are available to the public via the TIMBRE web site, and presentations at national and international conferences, to which also participants of the workshops, focus groups and questionnaires have been invited.

CHAPTER 4 Development of an Information System for Brownfield Regeneration as web-based information platform to provide solutions according to stakeholders' characteristics and information needs

4.1. Structure of the Information System for Brownfield Regeneration

The ISBR has been developed to more deeply understand brownfield stakeholders' characteristics and information needs and to provide them with customised information. In order to achieve these objectives and to be at the same a user-friendly tool, the ISBR has been structured in two main components, the web database and the ANN ranking methodology, which have been integrated by means of easy to use interfaces (Figure 6).

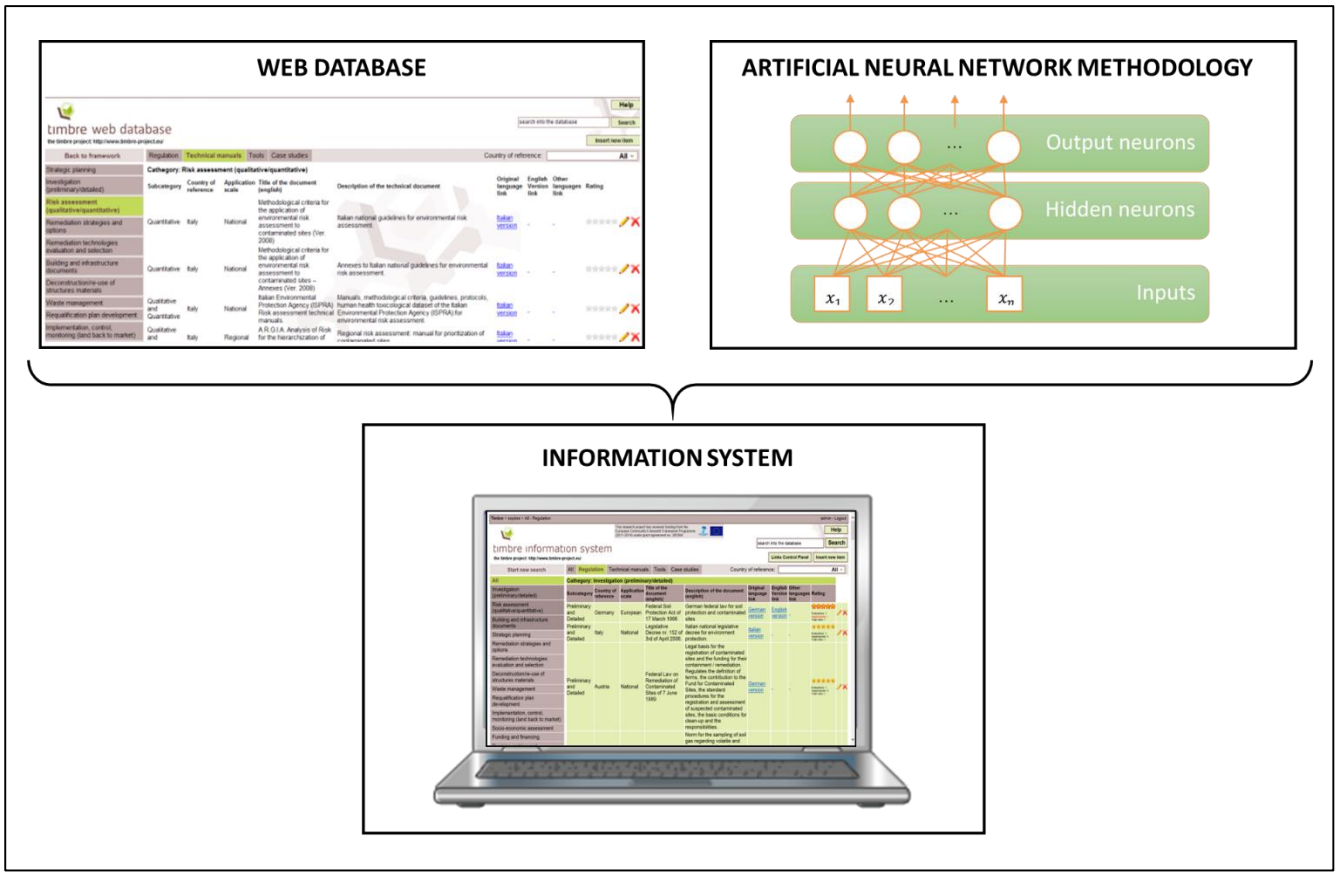

Figure 6 Information System for Brownfield Regeneration structure.

Within the web database, web-links to information of interest on brownfield regeneration have been collected, stored and made easily searchable by end-users. With the aim of guiding end-users among the variety of available information, the ISBR implements an ANNs methodology for the evaluation and ranking of the collected information providing end-users with the most suitable instruments for each phase of the brownfield regeneration process.

The development process of the tool can be schematically summarised by the following diagram (Figure 7), where it is possible to visualise when stakeholders have been involved into the process.

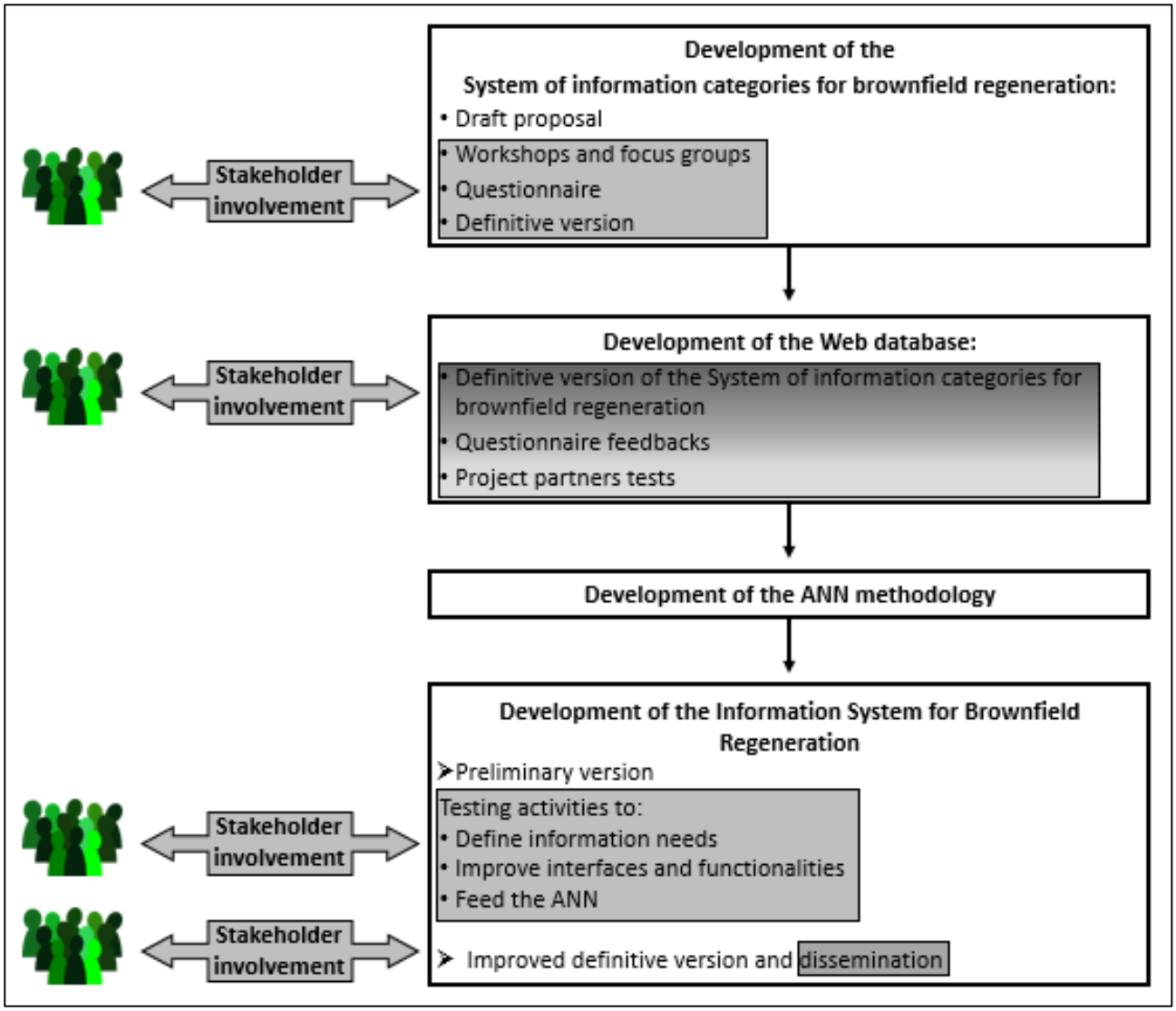

Figure 7 Development process of the Information System for Brownfield Regeneration and stakeholder involvement.

It is possible to notice that stakeholders have been involved in most of the process. An exception is represented by the step related to the "Development of the ANN methodology", where there was no meaning in involving stakeholders, but ANN experts.

In the next paragraphs, first the web database is described, followed by an explanation on how the ANN methodology has been implemented within the tool.

4.2. Information System web database for the collection of information

The web database collects information provided by TIMBRE project partners and by external stakeholders that have been involved along the development of the tool. The web database is aimed at storing and making available to end-users all the collected information about regulations, technical manuals, tools and case studies on brownfield regeneration. Specifically, it provides web-links to specific documents or websites where to download the needed information, documents and tools on brownfield regeneration.

The web database is structured according to the system of information categories for brownfield regeneration (Figure 8 based on Figure 5; Rizzo et al., 2015), which is composed of 13 information categories corresponding to the different idealised phases of the brownfield regeneration process. Web-links are stored into the tool according to the information category they belong to. Moreover, web-links are classified according to the type of information they refer to (i.e. Regulations, Technical manuals, Tools and Case studies).

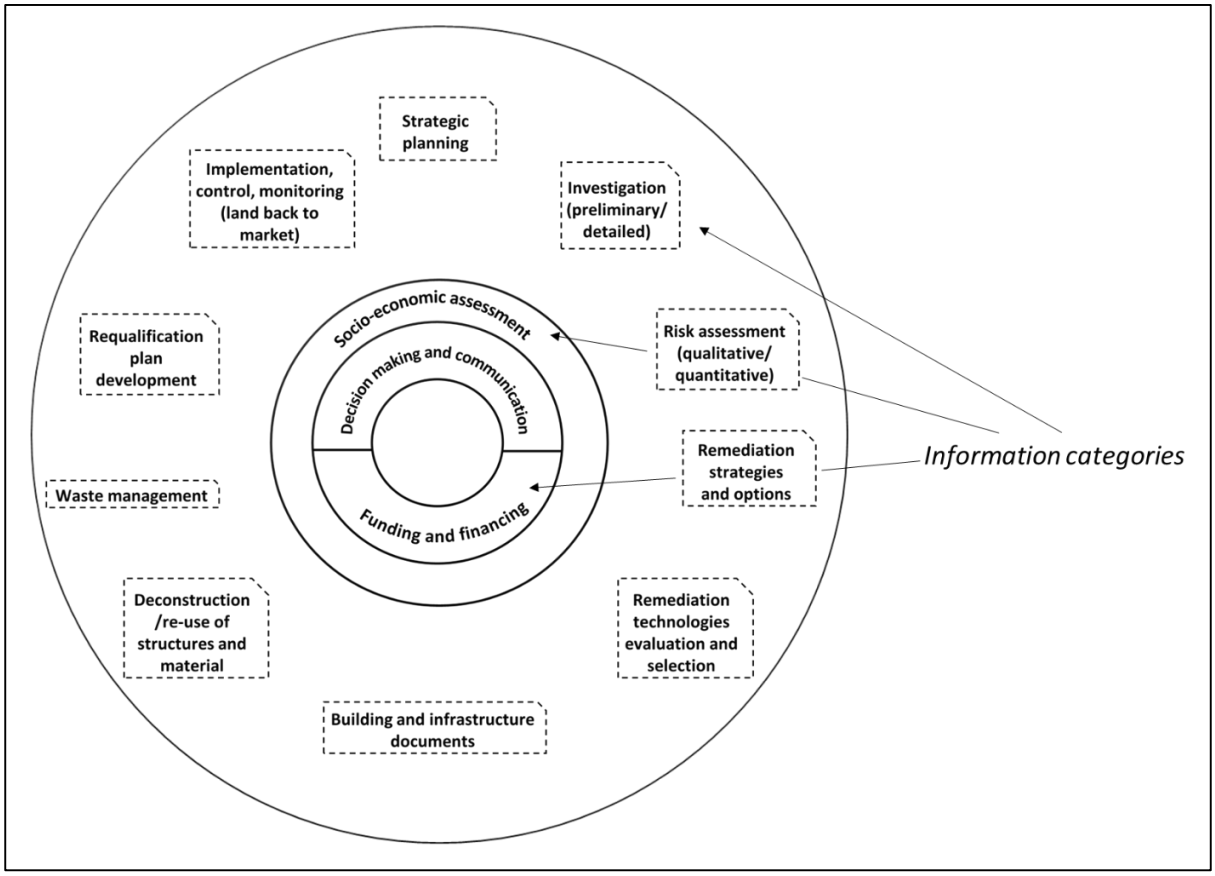

Figure 8 System of information categories for brownfield regeneration.

In order to include new web-links into the database, information such as title of the document, description with key words in English, country of reference and application scale is required. In the specific case of the information category "Remediation strategies and options", additional information such as technology name, technology type, target contaminants, performance, technology applicability conditions, etc. is requested in order to provide end-users with more detailed technical information on remediation technologies.

When searching for information, users, besides selecting the information category and the type of document, can make use of a functionality that filter web-links according to the country of reference in order to visualise all the information belonging to a specific country of interest. Finally, if users are interested in specific information but they are not sure about the related information category, they can perform a search by keyword.

4.3. Artificial Neural Network Methodology for the ranking of the information

Since it is not possible to know specific users' actions into the tool before they actually make them, there was the need for a ranking methodology able to guess users' needs from the behaviour of similar previous ones and therefore to provide each end-user with the most suitable information for each phase of the brownfield regeneration process according to specific characteristics, requirements and needs. Therefore, from the definition of the problem, it was clear that: 1) there is no a priori knowledge about the way to rank web-links (i.e., about the preference model of the users, dealing with different types of possible users); 2) the system should be able to learn from experience; and 3) the system should be able to perform effectively also in the presence of data gaps. The proposed solution to this ranking problem, which satisfies all the above mentioned conditions, is the use of ANNs (Mehrotra et al., 1997). Accordingly, an ANNs-based methodology has been implemented in order to learn from users, to improve ranking results with time and to provide the most relevant information to users according to their characteristics and needs.

Indeed, differently from algorithmic models, which require prior knowledge of the modelled event, ANNs (Mehrotra et al., 1997) are mathematical nonlinear regression models, which, after a so-called "learning phase", are actually able to infer the model underlying a set of given inputs and outputs used as a "training set". Another fundamental difference, which distinguish ANNs from common regression models and algorithmic models, is that ANNs can guess the "correct" output even when some inputs are unknown, by supplying responses by similarity. ANNs, therefore, are perfectly addressed to face the identified ISBR ranking problem. The presented methodology makes use of Feedforward Neural Networks (FNN) (Fine, 2013), which are specific types of ANNs where the output is the result of a nonlinear function of inputs and internal weights, which are constantly updated in order to supply better results. Each different web-link stored in the ISBR database is related to its own FNN, which supplies its ranking score. A FNN is graphically represented as a set of neurons connected together, in which the information flows only in the forward direction, i.e. from inputs to outputs.

The methodology makes use of a set of information collected during each search session about:

- the user performing the search;
- the user's search aim and other parameters associated with the search session;
- general statistics of the past sessions; and
- the scores given by the users to the obtained results.

A focus on descriptions of these inputs is reported in the following table.

Table 4 Descriptions of the ANN methodology inputs.

Inputs for the ANN methodology
"User related" inputs are data provided by the users during registration to the ISBR. They refer to specific user' characteristics stored on his/her profile page (which can be updated/modified as needed). More specifically these inputs are: - "Preferred language": the user is asked to indicate the preferred language when searching for information. According to this selection, the system provides a list of web-links where

documents are written in the user's preferred language, while the other links refer to material written in English, and afterwards in other languages.
- "Stakeholder category/ies the user belongs to": this information is used by the system in order to provide the user with the most visualised web-links by previous users belonging to the same typology of stakeholders.

"Session related" inputs are provided by the user during each search session, thus they can change for the same user from session to session and depend on the specific tasks he/she is using the ISBR for. These inputs are the following:
- "Aim of search": for each session the user is asked to indicate his/her search aim when using the ISBR. This information is used to provide tailored information to the user. A list of search aims is provided and the users can choose one option from the list or indicate a new particular search aim.
- "Country of reference": for each session, the user is asked to indicate the country where the needed information is intended to be applied. This information will affect the ranking of web-links, which will be provided in the following order: first links related to the selected country, then web links referring to the language indicated by the user as the preferred one, afterwards links to material written in English, and finally in other languages.
- "Selected information categories": in each session, the user is asked to select the information categories related to his/her main search aim.
- "Scores of information categories": after selecting the information categories, the user is asked to evaluate them, assigning a score from 1 to 5 (where 1 is associated to the worst evaluation and 5 to the best evaluation) according to his/her personal preferences and expertise.
- "Typology of information": after the selection of the information categories, the user can select also the typology of information of interest, choosing among "Regulation", "Technical manuals", "Tools" and "Case studies".

"Scores" inputs refer to the evaluation of the web-links contents (i.e., associated documents) provided by each user at the end of a search session according to the following criteria:
- "Pertinence": the user is asked to specify if a specific web-link's information is pertinent and related with his/her previously defined aim of search (yes/no answer);
- "Appropriateness": the user is asked to indicate if a specific web-link information is appropriate for the previously indicated information category/ies (yes/no answer);
- "Usefulness": the user is asked to evaluate the level of usefulness of the web-link information in achieving the specific aim of search (score: from 1 to 5, where 1 is associated to the worst evaluation and 5 to the best evaluation);
- "Clarity": the user is asked to evaluate the level of clarity of the web-link information, considering the description of concepts and the use of specific vocabulary (score: from 1 to 5, where 1 is associated to the worst evaluation and 5 to the best evaluation);
- "Reliability and accuracy": the user is asked to evaluate the level of reliability and, consequently, accuracy of the information that can be evaluated considering the quality and the trustworthiness of the source of information (score: from 1 to 5, where 1 is associated to the worst evaluation and 5 to the best evaluation);
- "Updating": the user is asked to evaluate the level of topicality of the information and the compliance with the latest regulatory frameworks (score: from 1 to 5, where 1 is associated to the worst evaluation and 5 to the best evaluation).

These evaluation scores are stored by the system and used to refine the ranking in search sessions performed by following users.

Finally, **"Statistics" inputs**:

- Number of clicks received by a web-link from users belonging to the same stakeholder category: it indicates the level of interest from the same stakeholder category for that web-link.
- Total number of clicks: it indicates the level of interest for a particular web-link.

These inputs have been chosen and designed with the specific aim of considering all possible inputs needed for tailoring users' search results, from the time users register into the tool, to the time they click on web-links and evaluate them and the related information.

More into detail, the different kinds of data required by the methodology are acquired and used in different phases of the ranking process:

- user related information is gathered when the user signs to the system;

- session related information is asked prior to every search (not mandatory);

- the aim of search can be selected from a list of predefined aims (which has been established as results of workshops) or inserted by the user (in the latter case, it is not possible for the system to use it in order to tailor the ranking);

- information category scores: when the user selects the aim of the search he/she is also asked to select and score the information categories the user is interested in;

- information typology: the user is asked to specify which information typology is of interest (i.e., Regulations, Technical manuals, Tools and Case studies);

- criteria scores: once the ranking of web-links is supplied as output by the system and the user selects some of the proposed links, the user is asked to leave a feedback about the associated document. These scores are used to refine and better tailor the results of future similar searches;

- statistics: the number of total clicks to the same information and the number of clicks generated by users belonging to the same stakeholder category are collected by the system session by session.

It has to be emphasised that, when including a new web-link in the tool, the user is asked to give an evaluation of the inserted item providing a score to the criteria: "clarity", "reliability and accuracy" and "updating". These criteria belong to the "Scores" inputs group and have been selected because, differently from the criterion "usefulness", they are independent from a specific search aim, thus they allow providing a first general evaluation of the document. This step, based on web-link first inclusion and scoring, constitutes the first iteration in the cyclic process (Figure 9).

The complete process of learning and supplying results is reported in Figure 9. The first step concerns the inputs provided by the user as user-related and session-related information. This information, alongside with the statistics of the past sessions are supplied to the processing unit, which outputs a rank position for each web-link collected in the dataset within each information category selected by the user. After the operation unit provides an output (as detailed in the paragraphs below), the user is asked to evaluate, for this output, the accessed web-links by scoring them with respect to specific evaluation criteria (Usefulness, Clarity, Reliability and accuracy, Updating described in Table 4). This

evaluation defines the user's "satisfaction" in relation to the aim of the search. On the basis of these scores, the internal weights used within the FNN processing unit (not to be confused with user's defined scores, please find detailed explanation in the next section) are adjusted in order to be more compliant with user's "perspective" and to provide more satisfactory results for future similar searches. Statistics are also updated according to user's clicks on specific web-links, which in general terms means that those web-links, which receive a higher number of clicks, are considered more interesting for the users. This information is also integrated in the ranking methodology.

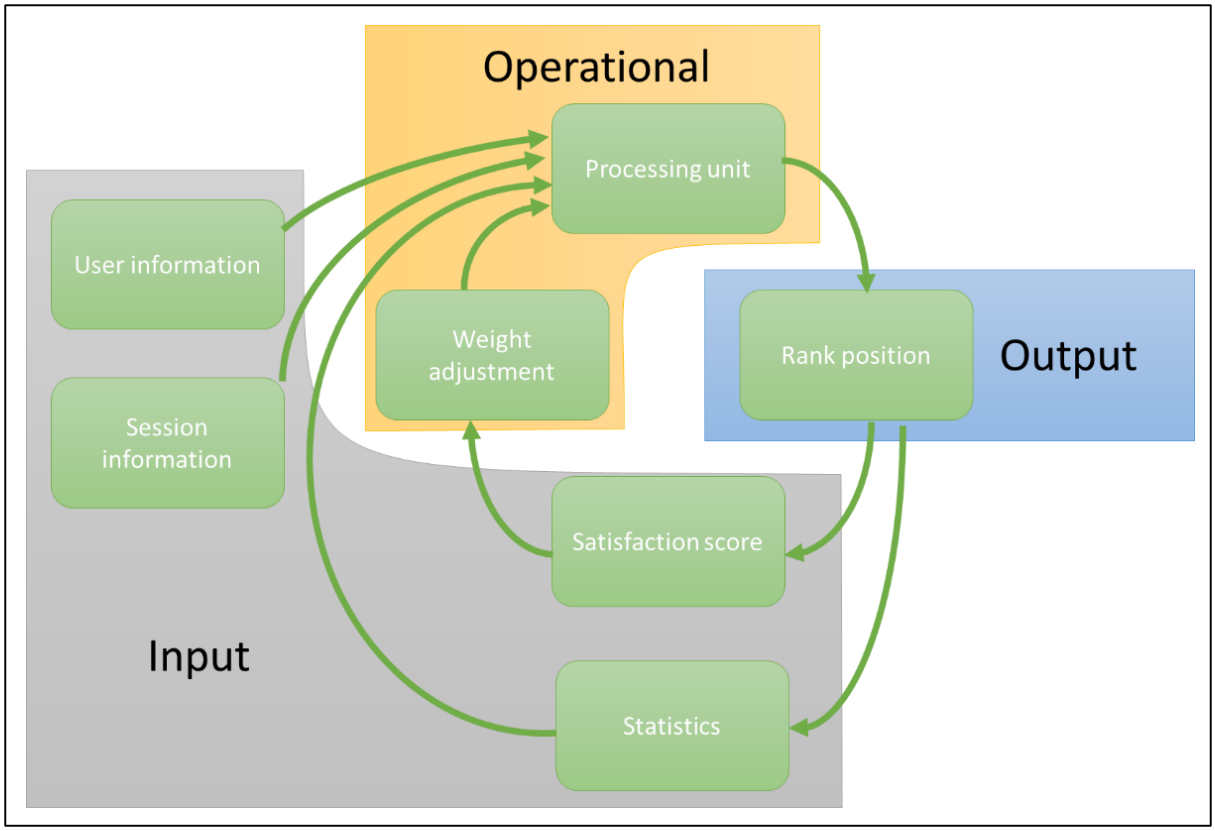

Figure 9 FNN learning and ranking process data flow.

As reported in Figure 9, the FNN operational part of the data flow consists of *processing unit* and *weight adjustment*. The processing unit is implemented by the FNN, while the weight adjustment is performed through the gradient descent method (Calafiore and Ghaoui, 2014).

Processing unit

According to Mehrotra et al. (1997), the FNN is shaped as a single layer perceptron (i.e. one of the possible learning algorithms in FNN that learns, using examples, to assign input vectors, i.e. samples, to different classes) with hyperbolic tangent (*tanh,* a sigmoidal function) as hidden neurons' activation function and weighted average (a linear function) as the single output neuron's function. All neurons are initially set with randomly selected activation functions' parameters (i.e. weights, w), which are then adjusted (updated) throughout the learning phase in order to provide the most accurate results. These initial random values are continuously improved by the application of Adaptive (On-Line) Training techniques (Fine, 2013), which allow to continuously improve parameters' values (i.e. weights, w) on the basis of data provided by users.

Formally, weights used as parameters are intended to be numbers in the [0,1] Real interval, while the *tanh* activation function is defined as:

$$y = g(x, w) = \sum_{i=1}^{Nc} \left[w_{Nc+1,i} \tanh \left(\sum_{j=1}^{n} w_{i,j} x_j + w_{i,0} \right) \right] + w_{Nc+1,0} \qquad \textit{Eq. 1}$$

Where x is the inputs vector (search aim, selected categories and their scores, number of clicks), w the weights vector (used and updated internally by the FNN), Nc the number of hidden neurons ($Nc + 1$ is the output neuron) and n is the number of inputs provided by the current user (i.e. the size of the input vector x). Conventionally, the parameter $w_{i,j}$ is assigned to the connection that conveys information from neuron j (or from network input j) to neuron i.

The backpropagation part of the process (i.e. the learning method used to train FNNs) is related to the adjustment of the weights used in Eq. 1 in order to improve FNN future results. This is obtained by:

- establishing a way to measure a distance between the obtained ranking score and the optimal score (which is derived by aggregating users' scores given to the link);
- calculating the weights which minimise the sum of the distances for all sessions (including the current one).

Weight adjustment

In order to improve FNN future results, weight adjustment has been used. The optimal solution y^{k*} (needed for evaluating cost and therefore update weights) represents the ranking score that the web-link should have reached according to the present user. It can be inferred for each session k by aggregating *a posteriori* user's scores related to the proposed visited web-links. More precisely, given that pertinence p and appropriateness a are veto scores (i.e. if a link is not pertinent or appropriate its optimal score should be 0 (details about pertinence and appropriateness are reported in Table 4), the weighted average of the other scores $s_1, \dots, s_4$ (i.e. usefulness, clarity, reliability and updating – for details see Table 4) is used. Weights related to scores ($ws_1, \dots, ws_4$) have been introduced in the formula to allow different level of importance for different scores. They have been all set to 1, meaning they are all considered of equal importance but could be changed in the future if needed. The optimal solution y^{k*} for session k is therefore reported in Eq. 2, while the selected cost function J, used in order to aggregate the distance between all past sections into a single cost number, is the least square function as reported in Eq. 3 where N is the number of observations and x^k the input vector for observation k.

$$y^{k*} = \begin{cases} 0 & p = \text{NO} \ \vee \ a = \text{NO} \\ \dfrac{1}{4} \displaystyle\sum_{i=1}^{4} \dfrac{ws_i \cdot s_i}{4} & \text{else} \end{cases} \qquad \textit{Eq. 2}$$

$$J(w) = \sum_{k=1}^{N} \left(y^{k*} - g\left(x^k, w\right) \right)^2 = \sum_{k=1}^{N} J^k(w) \qquad \textit{Eq. 3}$$

The gradient descent method optimises weights as observations increase. Weights for observation k are obtained on the basis of the gradient of past observations by following the cost gradient decreasing direction.

Output

The FNN, with adjusted weights, outputs a score for each link pertaining to the selected information categories and typologies of documents. The ranking of the links is then obtained by descendant ordering of these scores.

4.4. Information System functionalities and interfaces

The ISBR interfaces allow users to exploit several functionalities, grouped as follows:

- User profiling functionalities (i.e. registration and log in);
- Search functionalities (i.e. definition of the search aim; selection of the country of interest; selection of the information categories related to the pre-defined search aim and related scores; visualisation of results);
- Evaluation functionalities (i.e. evaluation of web-links during upload and during search for information);
- Filtering functionalities (i.e. sustainability filter, country of reference filter);
- Managing functionalities (i.e. upload of new web-links into the tool; modify or delete web-links; password recovery and modification; links control panel; expert user; help; log-out).

The main interfaces, which allow the functioning of the ISBR functionalities, are reported in Figure 10.

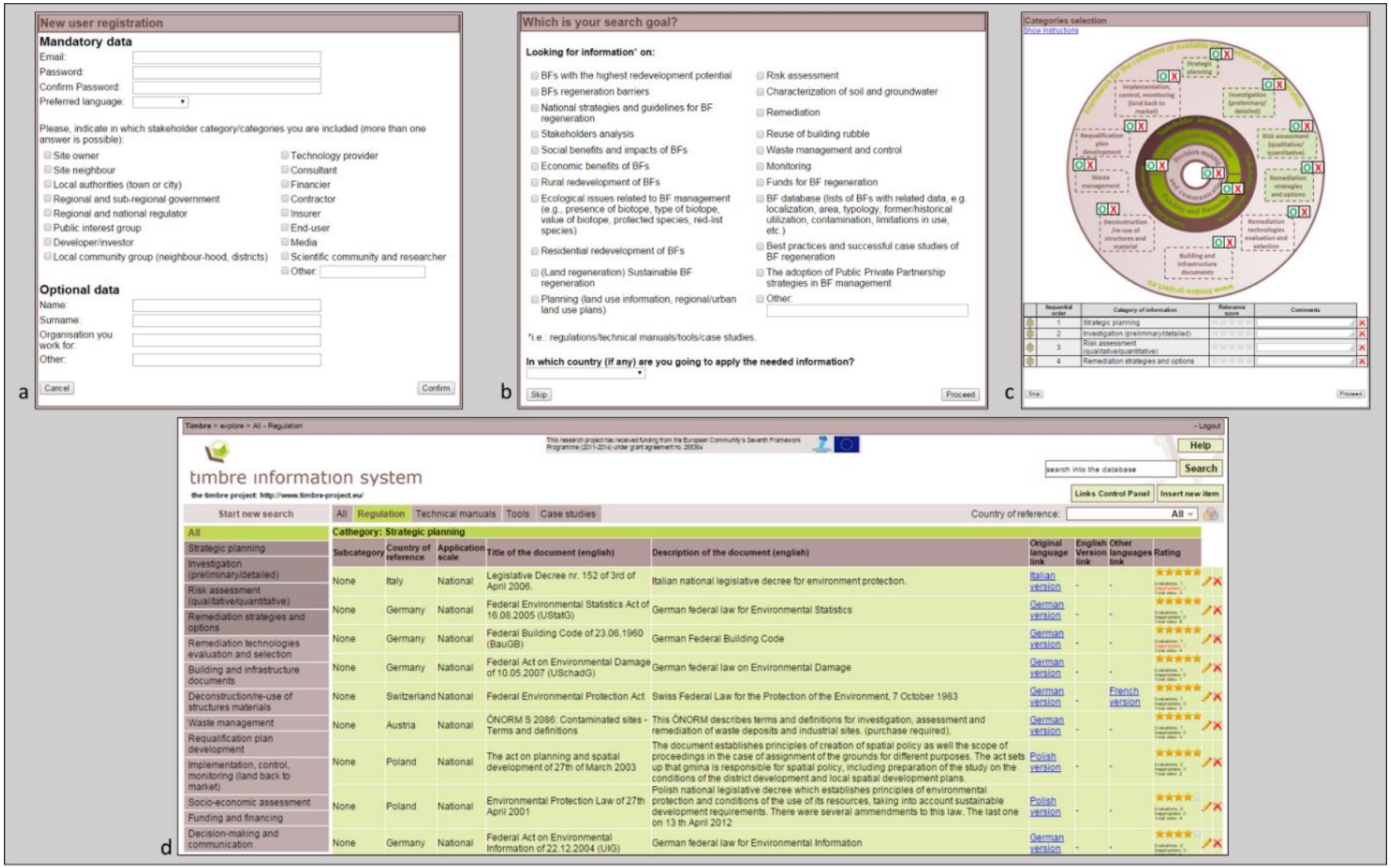

Figure 10 Screenshots of four ISBR graphical user interfaces: a) new user registration; b) definition of the search aim and selection of the country of interest; c) selection of the information categories related to the pre-defined search aim; and d) ISBR main interface.

The registration procedure (Figure 10a) requires new users to indicate, as mandatory data, their e-mail address, to choose a password, to indicate a preferred language and the stakeholder category/categories they belong to. As optional data, new users can indicate name, surname, and the organisation they work for. There is also a space for including additional information. Within the search aim definition interface (Figure 10b), users are asked to indicate their specific search aim, that is a specific information goal that the users want to achieve when using the ISBR. This information is used by the tool to provide customised information to each user. In the same interface, users are also asked to indicate the country where the needed information is intended to be applied. After indicating their search aim and the country of interest, users can visualise the system of information categories for brownfield regeneration (Figure 10c). Users can select the information categories of interest and attribute them a relevance score in the table where they are automatically listed after selection (relevance scores are described in Table 4). Finally, within the ISBR main interface (Figure 10d), users can visualise web-links according to the categories of information and the typology of document of interest. Furthermore, users can refine results by country of reference and by key word. Moreover, users interested in sustainable brownfield regeneration and sustainable remediation can filter information addressing these issues by clicking on the sustainable development icon, which is located at the right side of the bar where users can perform search by typology of document and country of reference. The sustainable development icon represents the three overlapping circles that symbolise the three sustainability pillars (i.e. the economic, the environmental and the social pillar), and answer to specific information needs identified along the development of the tool.

After users access the information of interest through the proposed web-links, they can evaluate the related information, according to the criteria usefulness, clarity, reliability and accuracy, and updating, by clicking on the stars reported in the rating column on the right. Finally, users can upload their own web-links using the button “Insert new item” and control if they are up to date by clicking on the button “Links Control Panel”.

4.5. Involvement activities to test and improve the Information System and more deeply understand stakeholders’ requirements

Stakeholders related to the TIMBRE case studies located in Czech Republic, Germany, Poland and Romania have been further involved during four workshops to test the ISBR, to “feed” the implemented ANN, and to gain feedbacks on the functionalities and interfaces in order to improve the tool accordingly.

The first workshop, held in Berlin (Germany) the 27th November 2013, involved 25 participants. The second workshop, organised in Brno (Czech Republic) the 29th November 2013, engaged 31 participants. The third workshop, organised in Bucharest (Romania) the 11th March 2014, involved 10 participants. Finally, the fourth workshop, held in Katowice (Poland) the 28th May 2014, involved 12 participants. Therefore, 78 stakeholders, international experts in brownfield management, tested the tool before its final release at the end of the Timbre project (July, 2014).

During the four workshops, the following stakeholder categories were represented: site owners (3), site neighbours (2), local authorities (8), region and sub-regional government (1), regional and national regulators (7), local community groups (4), public interest groups (5), developer/investors (1),

technology providers (2), consultants (10), contractors (3), end-users (5), media (1), scientific community and research (26).

Each workshop was structured in three parts: first, an introductory general presentation to explain the ISBR was delivered; second, a webinar-type of presentation was provided to allow stakeholders to perform a step-by-step guided test on the tool; third, a questionnaire on the usability and performance of the tool was submitted, followed by a discussion session to foster dialogue between potential users and developers of the tool and to wrap-up main conclusions. This way, the ISBR developers could collect all the comments and suggestions recommended by the participants to improve the tool accordingly.

It has to be noticed that, since the tool is freely accessible by internet, the total number of users is constantly increasing and the results presented in Chapter 6 refer to data acquired in July 2015.

SECTION C – APPLICATION TO CASE STUDIES AND OUTCOMES

CHAPTER 5 Identification of stakeholder categories, perceptions, concerns, attitudes and information needs in five European countries

The involvement methodology described in Chapter 3, adopted to understand stakeholders' categories, perceptions, concerns, attitudes and preliminary information needs, has been applied to stakeholders directly related to the TIMBRE case studies from the following countries: Czech Republic, Germany, Poland and Romania (see Table 5). One additional country is Italy, where stakeholders have been involved on the basis of professional networks.

The involvement methods (i.e. workshops, focus groups, and questionnaire) applied in the different countries and the number of involved stakeholders are reported in Table 5.

Table 5 Number of stakeholders involved within each engagement method, for different countries and cities.

	Romania	Poland	Czech Republic	Germany	Italy
WORKSHOP	60 (Hunedoara)	70 (Zielona Góra)			
FOCUS GROUP	15 (Bucharest)		9 (Ostrava)		
ON LINE QUESTIONNAIRE (number filled in / number distributed)	17/47	7/39	9/28	12/23	10/45

Workshops

The first engagement event was a workshop that brought together about 60 actors interested in brownfield regeneration in Romania. This event took place in Hunedoara, in October 2011 (Bartke et al., 2012). During the Hunedoara workshop, local and national stakeholders have met in order to establish a first acquaintance with them. The instauration of a good relationship was considered to be a crucial step to guarantee stakeholder involvement also in the subsequent activities. The involved categories of stakeholders were the following: site owner, local authorities, region and sub-regional government, regional and national regulator, developer/investor, consultant, contractor, media, scientific community and researcher and end-user. Another workshop was held in Poland, in Zielona Góra in March 2012 (Bartke et al., 2012). Nearly 70 people representing public administration of national, regional and local levels, non-governmental organisations and various experts such as architects, experts in spatial planning and scientists participated in this workshop.

Focus groups

Two focus groups have been organised, one in Bucharest (Romania) in January 2012 and one in Ostrava (Czech Republic) in October 2012. The focus group in Bucharest involved 15 participants, while the one in Ostrava brought together 9 individuals.

Considering that brownfield regeneration in Romania is still at an early stage with regard to perceived needs, knowledge/expertise on what revitalisation involves and actual revitalisation experience, the

Bucharest focus group aimed to provide a hypothetical categorisation encompassing all phases of brownfield regeneration to collect stakeholders' perceptions and information needs. The represented stakeholder categories were the following: site owners, contractors, technology providers, regional and national regulators, scientific community and researchers. The Ostrava focus group brought together local and regional stakeholders from the Moravian-Silesian Region, a region with a large number of brownfields and substantially more expertise but also divergences in viewpoints with regard to regeneration strategies, compared to Romania. The involved stakeholder categories were: site owners, researchers, consultants, local authorities, site neighbours, public interest groups.

On-line questionnaire

On the basis of the outcomes from workshops and focus groups, a questionnaire was developed and submitted to stakeholders from the case studies located in Czech Republic, Germany, Poland and Romania and other "external" stakeholders, including Italian stakeholders. They were asked to respond to the online questionnaire in order to collect information on their attitudes on the brownfield regeneration process and feedbacks on the proposed categorisation system for the collection of information on brownfield regeneration. The respondents belong to all the categories of stakeholders reported in Table 2, with the exception of the "Insurer" category.

In the following paragraphs, the obtained results of the engagement process are presented. These preliminary results contribute to understand who the stakeholders of brownfield regeneration are, which their roles are, and what they know and expect from the regeneration process. The results are structured in four main sections: first, the identification of representative categories of stakeholders is outlined followed by stakeholders' profiles: this helps to understand their roles. Then, identified stakeholders' perceptions, concerns and attitudes are described. Therefore, a preliminary discussion on stakeholders' information needs is reported. The latter is correlated with the categories of stakeholders and their main concerns, to identify what kinds of stakeholders are likely to be interested in certain categories of information.

5.1. Identified categories of stakeholders

The categorisation of stakeholders is the result of a discussion carried out with the TIMBRE consortium together with experts from the project's International Advisory Board (IAB). The list of categories of stakeholders and of the sub-groups to be involved in the participatory process is reported in Table 6.

Table 6 Stakeholder categories identified and selected for the engagement process.

Stakeholder category	**Sub-group**
Site owners	Landowner/Problem owner, Subsidiary interest group
Site neighbours	Immediate (< 1km), further afield
Local authorities (town or city)	Local authorities dealing with Urban planning, Environmental health, Soil/Groundwater protection
Region and sub-regional government	Region and sub-regional authorities dealing with Spatial planning and land management
Regional and national regulators	Protection agencies dealing with Soil/Groundwater protection, Waste, Environmental management, Occupational Health and safety, Preservation order, Regional Development
Local community groups (neighbourhood, districts)	Local residents and business users dealing with social issues

Public interest groups	NGOs, Grassroots movement
Developer/investors	Market actors Re-use planners
Technology providers	Companies that develop, produce and sell innovative solutions for environmental problems, Innovation seekers
Consultants	Designers, Environmental experts, Ecologists, Town planners, Marketing agents
Financiers	Public, Private companies
Contractors	Companies providing remediation, Infrastructure, Construction, Landscaping, Worker's health & safety
Insurers	Companies which support Risk transfer, Carrier of ongoing risk, Carrier of residual risk
End-users	Occupier, Residents, Businesses, Leisure, and Casual visitors
Media	Press (TV and Radio), Web, Print media, Other
Scientific community and research	Students, Natural science researchers, Social science researchers, Engineering science researchers, Other
Other	

Source: TIMBRE consortium & International Advisory Board.

5.2. Stakeholders' profiles

In order to define the spectrum of stakeholders that filled in the questionnaire, their role and profile was described by the type of organisation they are working for, their stakeholder categories and their area of expertise. Identifying the roles and profiles of stakeholders is aimed, as a first step, at distinguishing the different views of stakeholders involved in the brownfield regeneration process.

More than two-thirds of the stakeholders who took part in the questionnaires belong to public sector organizations (69%), followed by those belonging to the private sector (15%) and to research organizations (11%). Non-for-profit organisations are the least represented among the respondents (only 4%).

The categories of stakeholders selected by the respondents (see Figure 11) overlap for most stakeholders, which means that most of them indicated to belong to more than one stakeholders' category, with an average of 1.7 categories per respondent. The most represented stakeholder categories are regional and national regulators (17.2%), and consultants (17.2%), followed by members of the scientific community and researchers (16.1%). Percentage of consultants (17.2%) is higher than percentage of private sector (15%) because, as highlighted above, stakeholders could select more than one category, and several stakeholders proved being consultants, even if their main activity can be in another sector, like academia or even in the public sector. All categories with the exception of "insurers" have obtained at least one selection. As a result it was possible to collect information from almost all the relevant categories of stakeholders needed for the objectives of this research. The categories with low percentages of participation must be treated with caution, as they are based on the responses of few individuals and bar generalisation. Despite this fact, the identification and the overall number of respondents allows reporting results which bear potential conclusions of interest.

It is also possible to notice that the first most represented stakeholder category "Regional and national regulators" has been selected mostly by Romanian stakeholders (12.6%), followed at great distance by German (3.4%) and Italian (1.1%). This partly reflects the greater availability of respondents from the regulator category in Romania, given that one of the TIMBRE consortium partners was a national-level regulatory organization. At the same time, the relatively high number of regulators, compared to the near-absence of consultants in Romania, is symptomatic for an emergent brownfield market

that has not been yet opened up to sustained regeneration processes (Alexandrescu et al., 2013). The second most represented stakeholder category "Consultant" has been selected mostly by German (8.0%) and Polish (5.7%) stakeholders, followed by Czech (2.3%) and Italian (1.1%). The third most represented stakeholder category "Scientific community and researchers" has been selected in comparable proportions by stakeholders from all the countries analysed.

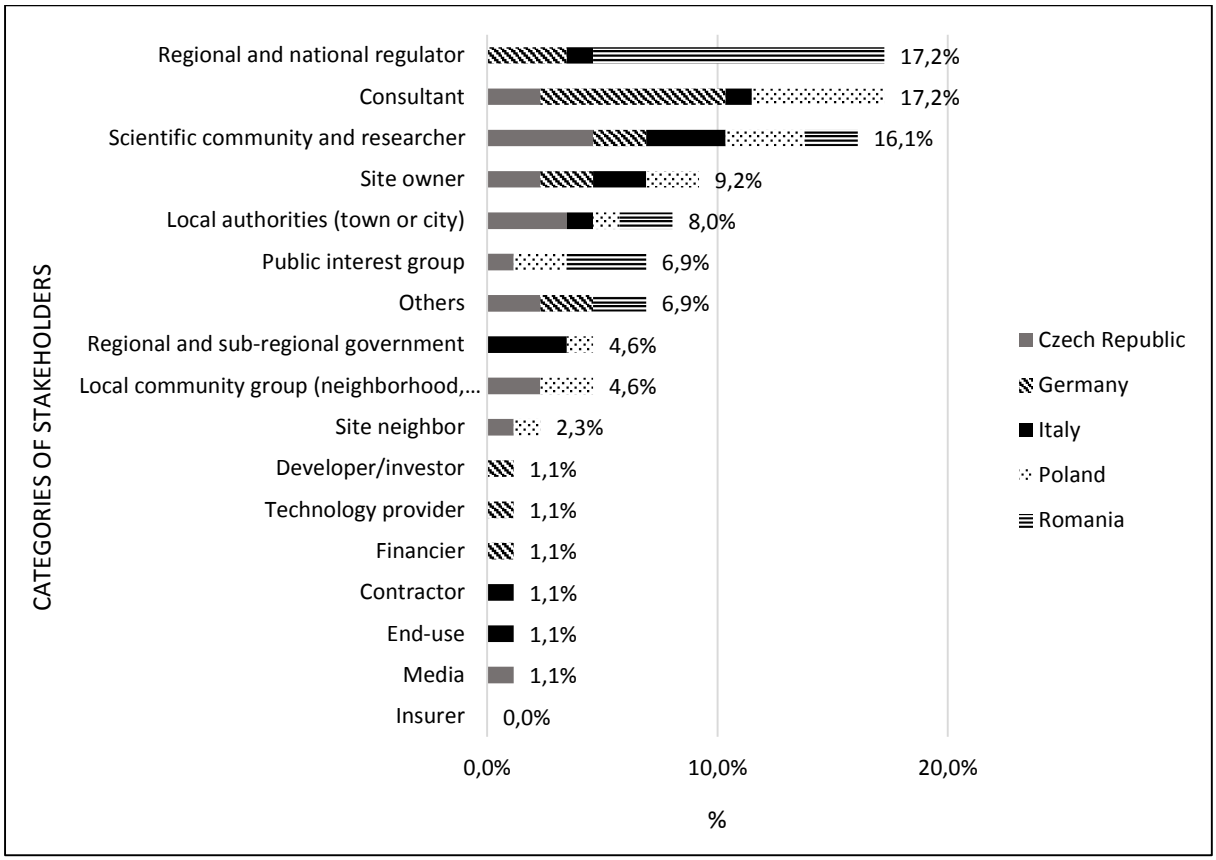

Figure 11 Graph representing the distribution of answers, within the indicated stakeholder categories, given by respondents from the five countries.

Considering the areas of expertise described (see Figure 12), one can observe that the most represented areas are: Characterisation/monitoring/control (24.2%), followed by Decision making process (20.5%) and Risk assessment (15.2%). Each of these was chosen by stakeholders from the five countries in comparable proportions.

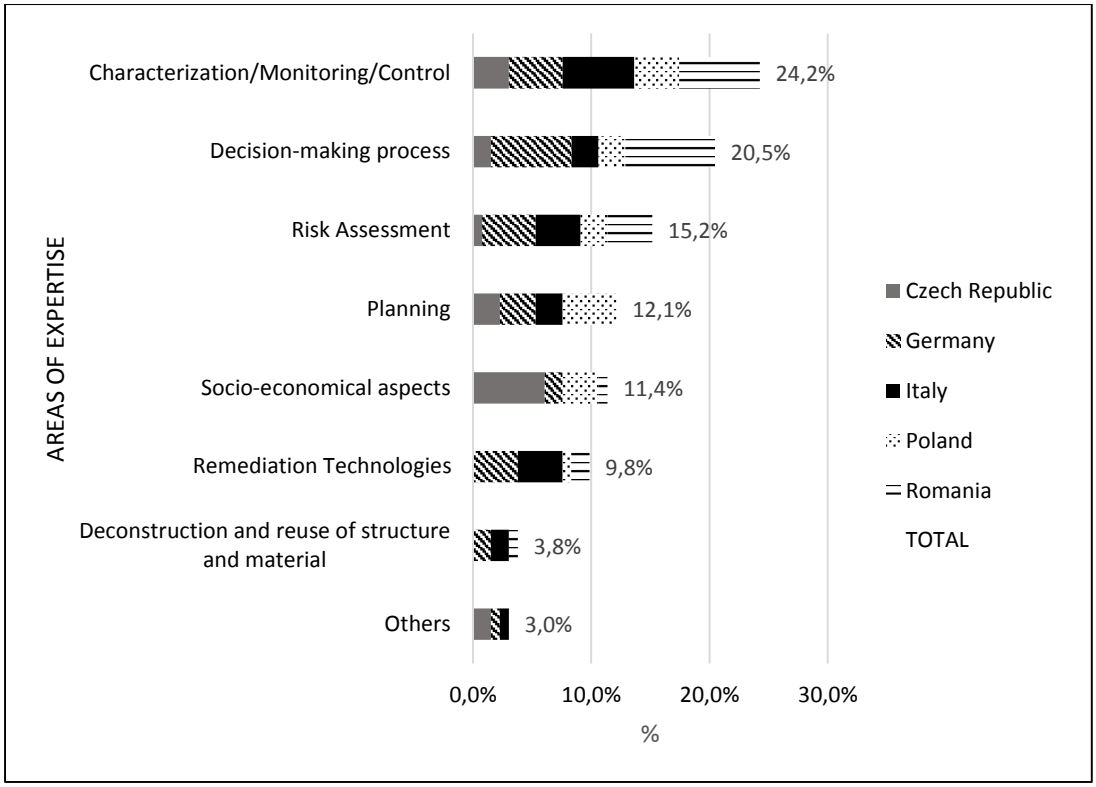

Figure 12 Graph representing the areas of expertise given by respondents from the five different countries.

Stakeholders provided also a brief description of their work activity, past or present, related to brownfield regeneration. The described activities can be summarised under three categories: i) brownfield regeneration planning and decision making (e.g. urban planning, creating redevelopment scenarios, assessment of investment costs, decision making and involvement of stakeholders), ii) carrying out technical tasks (e.g. characterisation, risk analysis, remediation, disposal of waste, monitoring), and iii) providing information to interested parties (e.g. provision of inventories of brownfields, media activities).

5.3. Stakeholders' perceptions, concerns and attitudes towards brownfields

In this paragraph, a more detailed characterisation of stakeholders in terms of their subjective, and at the same time practice-based, orientation towards brownfield regeneration is provided.

5.3.1 Stakeholders' perceptions

Stakeholders' perceptions regarding brownfields have been identified by the analysis of the definitions provided by respondents through open-ended questions, in comparison with the CABERNET definition (cf. Oliver et al., 2005). Five main issues identified within the CABERNET definition (i.e. brownfields are likely: affected by former uses, derelict/underused, affected by real or perceived contamination, located within urban areas, requiring intervention) have been analysed by checking how many of these issues were explicitly mentioned by each respondent. The stakeholders, subdivided into five groups according to their respective country, clearly differentiate themselves in how they describe brownfields.

Figure 13 shows radar graphs, where the tips of the pentagon represent the five characteristics identified within the CABERNET definition. Within each graph, the percentage of respondents that explicitly included the characteristics within the definition they provided is reported (the centre of the pentagon corresponds to 0% of respondents, while the most external line indicates the 100%).

First, the main differences are those in the number of characteristics mentioned. This ranges from all the characteristics being mentioned, albeit with different frequency, in Germany and Italy, to almost only one characteristic being mentioned, in the case of Romania. Czech Republic and Poland occupy intermediate positions, with respectively three and four issues being mentioned.

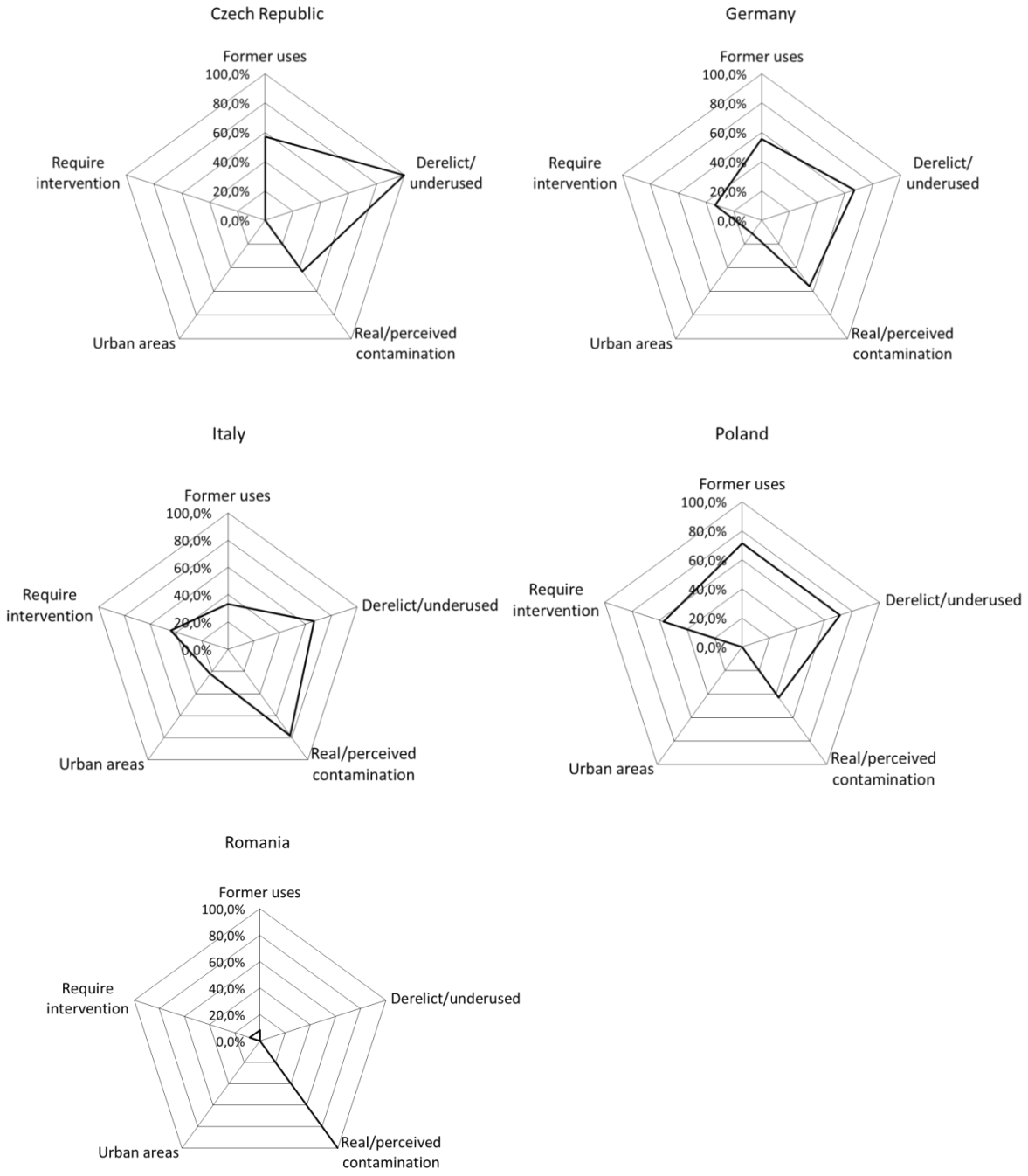

Figure 13 Radar graphs representing how respondents from the five countries describe a brownfield.

What is not indicated in Figure 13, but is worth mentioning, is that some definitions provided by the respondents pointed out an aspect that is not in the CABERNET definition: this is the lack of economic attractiveness that may characterise brownfield land. These specific definitions described brownfield land as a land that is not economically worth "developing", of any interest for the market, not

developable without financial support and, at the same time, unable to attract investors and financial investments.

5.3.2 Stakeholders' concerns

The presence of brownfields does raise concerns among the stakeholders interviewed (see Figure 14).

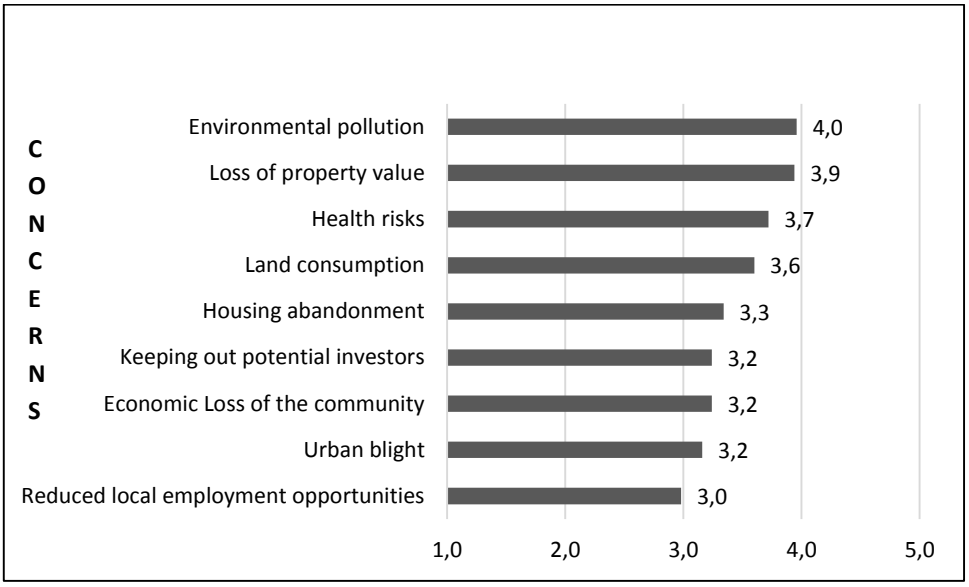

Figure 14 Bar chart representing the mean of the points provided by the respondents for the 9 proposed concerns. Mean values can range on a scale from 1 ("very low concern") to 5 ("very high concern"). Respondents were allowed to skip the evaluation of concerns. The total number of respondents for this question is 50.

All the entries have obtained a significant score showing that the presence of a brownfield raises different concerns to the people who have to deal with them or are affected by their presence. The results are presented without a breakdown by countries because the trend was similar in all of them. The two entries with the highest rate are the concerns for environmental pollution (mean equal to 4) and for the loss of property value (mean equal to 3.9) of the surrounding area. Both correspond to a high level of concern. On the other end, the entry that generates the least concern among experts in brownfield regeneration is the reduction of local employment opportunities. However, the mean values for all the concerns do all range between mean values of 3 and 4, indicating that all these concerns are relevant for the respondents and cannot be neglected. Other specific concerns that have pointed out by the respondents and that are not reported in the figure are the following: future profitability of the municipality, development paralysis (due to the inability to add new factories, plants, establishments or to expand the existing ones), worsening of the image of the owner, reducing the advantages generated by the spatial aesthetic of the surrounding area, and worsening of the image of the town. It becomes clear that not merely the sheer complexity but also the significant extent of concerns drive the persistence of brownfields dereliction and the reluctance in regeneration.

5.3.3 Stakeholders' attitudes

Stakeholders' attitudes indicate under which conditions stakeholders consider the brownfield regeneration process worthwhile, ranging from an "A" scenario (regeneration should generate short-term economic benefits) to a "D" scenario (in which the social and environmental benefits are deemed predominantly important, regardless of economic return). There are two intermediate scenarios –

called “B” and “C”- in which the economic benefits are equal or smaller than the costs, respectively (see Figure 15).

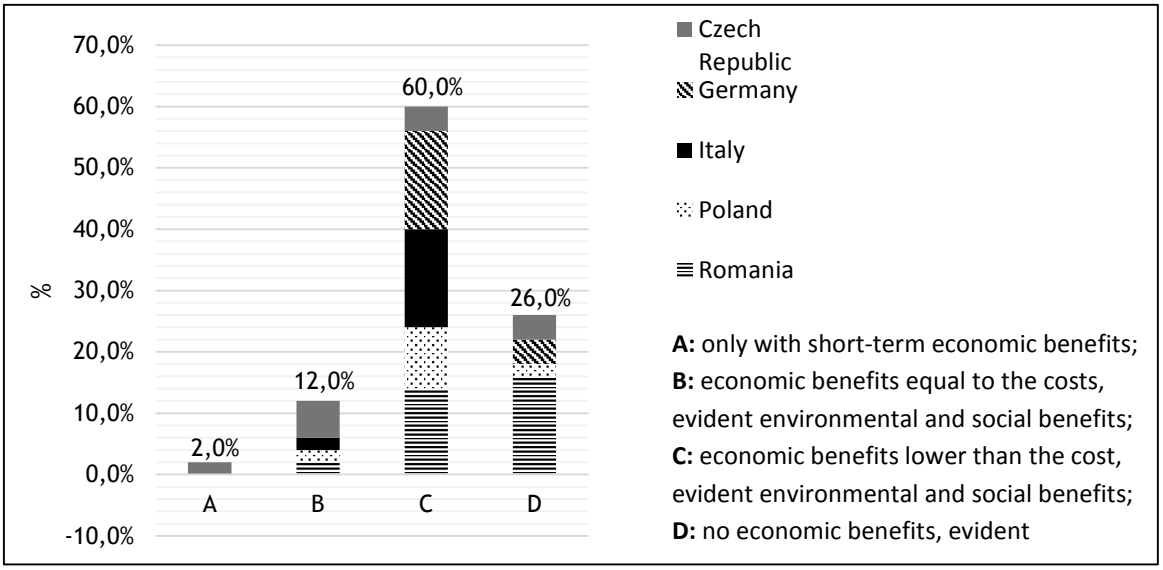

Figure 15 Stakeholder’s attitudes towards brownfield regeneration process.

Of the four options, C and D are the most frequently selected by the respondents. This is not surprising, given that most respondents work in the public sector and are, therefore, likely to see the regeneration of brownfields as a “public good”, and thus placing mere economic benefits in a secondary position. Analysing the answers to the open-ended questions, however, provides a more nuanced picture of stakeholder attitudes. On one hand, it is generally recognised that environmental and social benefits can generate, as a consequence, economic benefits in the long term. On the other hand, it is often noted that economic dynamics cannot be avoided and should be always considered. In addition, a consistent number of respondents pointed out the necessity to identify the financial sources that should cover the economic costs of the regeneration of a brownfield when this will not generate profits in the short term. Figure 15 suggests an interesting inter-country difference. Whereas for the Czech Republic, Germany, Italy and Poland most responses cluster around option C, with lower proportions of respondents selecting B or D, for Romania the pattern is skewed towards option D. Corroborating this with the fact that brownfield redevelopment is in its initial stages in Romania (Cobârzan, 2007), it can be imagined that Romanian stakeholders might lack adequate knowledge on a realistic balance between social and environmental benefits on the one hand and economic costs on the other, in regeneration.

5.4. Preliminary stakeholders’ information needs and feedbacks to the proposed categorisation system for the collection of information on brownfield regeneration

Based on stakeholders’ inputs received during workshops and focus groups, the categorisation system for the collected information was created. The information categories, encompassing all phases of brownfield regeneration process, were shared and agreed by participating stakeholders (see Figure 5). This section addresses the range of information needs of the consulted stakeholders. One of the main findings is that they have settled on a number of 13 information categories, which suggests that this is the range of information that they deem useful. Even if they were offered the opportunity to expand this number, the resulting categories appear to capture the information needs of a relatively diverse set of users of brownfield information. The sections below show, for a selection of stakeholder groups, what categories of information figure as their top choices.

5.4.1 Stakeholders' groups and information ranking

In order to obtain relevance rankings with a low dispersion of data, the categories of stakeholders have been rearranged into five groups of stakeholders with similar characteristics, as described below. The original categories included in the questionnaire are given in brackets:

- Group 1: Site owners (Site owners);
- Group 2: Authorities (Local authorities; Region and sub-regional government; Regional and national regulators);
- Group 3: Problem holders (Site neighbours; Local community groups; Public interest groups; End-users);
- Group 4: Services providers (Developer/investors; Technology providers; Consultants; Financiers; Contractors; Insurers; Media);
- Group 5: Scientific community and research (Scientific community and research).

From the most popular relevance ranking for each of the five groups of stakeholders, it is possible to notice that the information categories "Strategic planning" and "Investigation" are always ranked in the *top five* information categories (see Table 7).

The observed range of first choices (highest number of choices) is, however, limited to three information categories out of five possible ("Strategic planning", "Investigation" and "Remediation strategies and options"). In terms of first choices, for example, both site owners and problem holders choose strategic planning, while authorities and service providers value information on brownfield investigation. For the scientific and research community the most valuable is information on remediation strategies and options.

Table 7 Relevance rankings for the five groups of stakeholders. The 5 most relevant information categories for each group of stakeholders are highlighted in grey.

Group 1 site owners	Group 2 authorities	Group 3 problem holders	Group 4 services providers	Group 5 Scientific community and research
Strategic planning	**Investigation (preliminary/detailed)**	**Strategic planning**	**Investigation (preliminary/detailed)**	Remediation strategies and options
Funding and financing	**Strategic planning**	Funding and financing	Risk assessment (qualitative/quantitative)	Socio-economic assessment
Socio-economic assessment	Risk assessment (qualitative/quantitative)	**Investigation (preliminary/detailed)**	**Strategic planning**	**Investigation (preliminary/detailed)**
Investigation (preliminary/detailed)	Remediation strategies and options	Socio-economic assessment	Funding and financing	Decision-making and communication
Risk assessment (qualitative/quantitative)	Funding and financing	Remediation strategies and options	Remediation technologies evaluation and selection	**Strategic planning**
Remediation technologies evaluation and selection	Decision-making and communication	Risk assessment (qualitative/quantitative)	Building and infrastructure documents	Funding and financing
Implementation, control, monitoring (land back to market)	Socio-economic assessment	Decision-making and communication	Remediation strategies and options	Risk assessment (qualitative/quantitative)
Building and infrastructure documents	Remediation technologies evaluation and selection	Remediation technologies evaluation and selection	Decision-making and communication	Remediation technologies evaluation and selection
Remediation strategies and options	Requalification plan development	Building and infrastructure documents	Socio-economic assessment	Deconstruction/re-use of structures materials

Decision-making and communication	Building and infrastructure documents	Requalification plan development	Requalification plan development	Implementation, control, monitoring (land back to market)
Requalification plan development	Deconstruction/re-use of structures materials	Deconstruction/re-use of structures materials	Implementation, control, monitoring (land back to market)	Building and infrastructure documents
Deconstruction/re-use of structures materials	Waste management	Waste management	Waste management	Waste management
Waste management	Implementation, control, monitoring (land back to market)	Implementation, control, monitoring (land back to market)	Deconstruction/re-use of structures materials	Requalification plan development

Considering the data in Table 7, a selection of the top five information categories for each group of stakeholders has been analysed further. To this end, for each group of stakeholders, it has been decided to assign a score from 1 to 5 to each information category of the selection (consequently one represents low relevance and five represents high relevance, in a sort of automatic assignation process). The obtained histogram is reported in Figure 16.

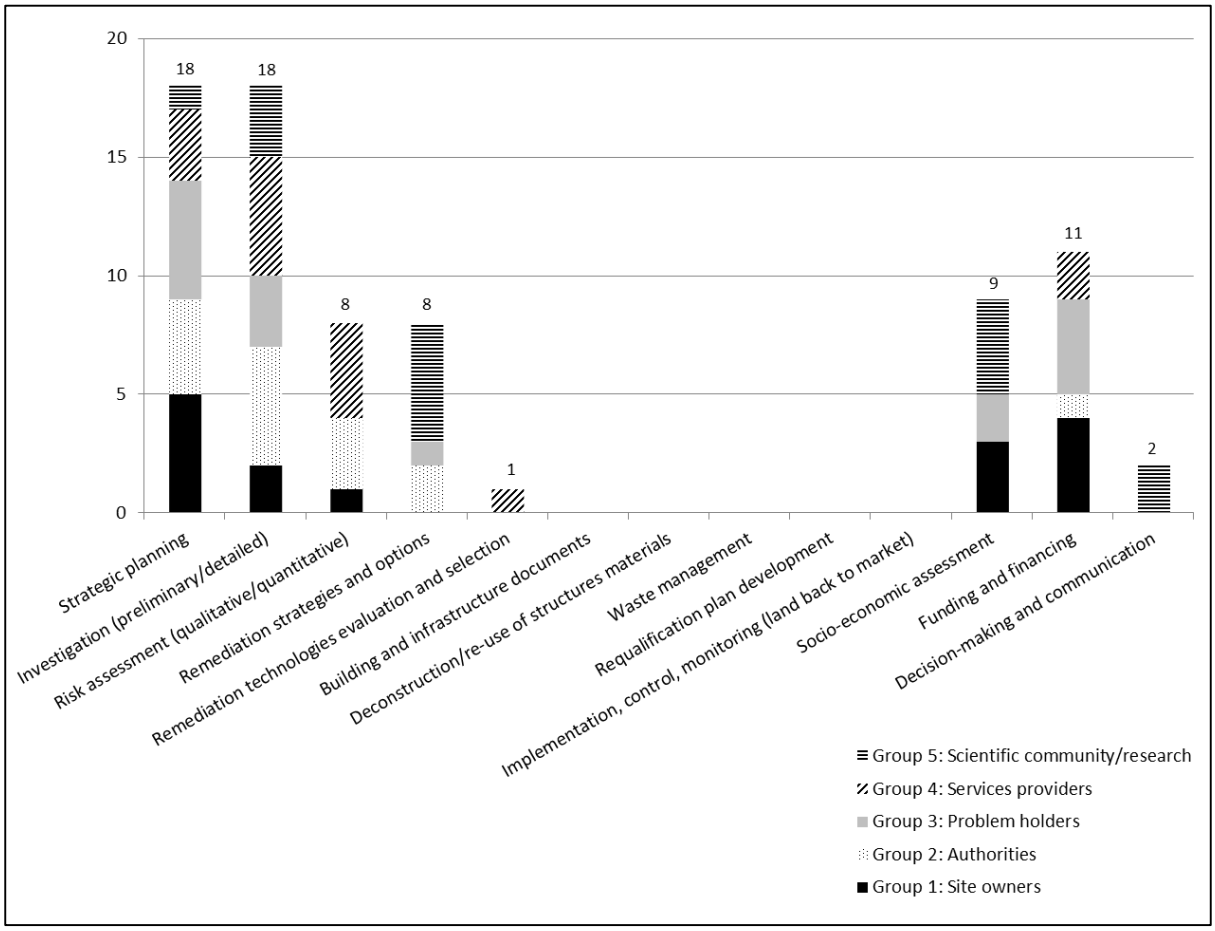

Figure 16 Histogram representing the distribution of scores achieved by the information categories according to the preferences provided by the five groups of stakeholders. The values have been computed by assigning the first ranked information category 5 points, the second one 4 points and so on up to the fifth category, which received 1 point.

Figure 16 (derived from Table 7) represents the distribution of scores achieved by the thirteen information categories according to the preferences provided by the five groups of stakeholders. This

diagram shows that *site owners* and *problem holders* are primarily interested in gaining information about strategic planning and funding and financing, which is reasonable considering the role they play in brownfield regeneration.

Authorities, listing investigation, strategic planning and risk assessment in the first top three positions, present a strong similarity with *services providers*, which keep investigation in first position and simply switch strategic planning and risk assessment.

Finally, the *scientific community and research group* lists in the two first positions remediation strategies and options and socio-economic assessment. This represents an interesting insight, which to some extent anticipates and reveals the emerging interest of this stakeholder group for information supporting sustainable remediation option appraisal according to environmental, economic and social assessments.

5.4.2 Stakeholders' concerns and information categories

One expects that the relevance of the information categories will vary not only in relation to the group of stakeholders, but also depending on the level of concern with specific brownfield problems. Accordingly, the relationships between the selected relevant information categories and the identified concerns (see Table 8) have been investigated, considering only the categories of information ranked in first position for relevance. In the contingency Table 8, only those responses that indicated a high or very high level of concern with the different problems generated by the presence of brownfields have been included. This allows making tentative inferences on the kinds of concerns that stakeholders interested in specific information categories might have. In what follows, the choice of information categories for each of the five stakeholder groups will be discussed, adding where appropriate insights from the cross-tabulation between information categories and brownfield concerns. Given that the information categories discussed in 5.4.1 are based on the top five choices, while the information categories analysed in 5.4.2 relate to the top first choice, the results in the two sections are not directly comparable, but, considered together, can provide a wider picture of the analysed problem.

Table 8 Number of times a specific information category has been selected as the most relevant (i.e. first position for relevance) by a stakeholder who identified a specific concern as "High". Cells with values above 5 have been coloured in grey.

		INFORMATION CATEGORIES													TOTAL (Mean = 18.5)
		Strategic planning	Investigation (preliminary/ detailed)	Risk assessment (qualitative/ quantitative)	Remediation strategies and options	Remediation technologies evaluation and selection	Building and infrastructure documents	Deconstruction/ re-use of structures materials	Waste management	Requalification plan development	Implementation, control, monitoring (land back to market)	Socio-economic assessment	Funding and financing	Decision-making and communication	
CONCERNS	Environmental pollution	6	7	2	2			1			1	3	2		24
	Loss of property value	7	10	1	1	1		1				2	2	1	26
	Health risks	6	5		2			1			1	4	2		21
	Land consumption	5	5		1		1	1			1	3	1		18
	Housing abandonment	4	4	1			1					4	1		15
	Keeping out potential investors	3	6	1	1			1			1		2		15
	Economic loss of the community	1	6	1	2			1			1	2	2		16
	Urban blight	2	2	1	1		1	1			1	2	1	1	13
	Reduced local employment opportunities	1	3	1								2	2		9
TOTAL (Mean = 14.3)		35	48	8	10	1	3	7			6	22	15	2	

Starting from the breakdown of the results by the five stakeholder groups (Table 7 and Figure 16), this reveals some noteworthy patterns, elucidated here in relation with evidences from Table 8.

The *site owners* appear to be mostly concerned about strategic planning, followed by funding and financing. While this is not surprising, as the presence of brownfields poses both planning and financial challenges, the third selected category – that of socio-economic assessment – is unexpected and invites potentially new interpretations. It suggests that site owners pay attention to the wider social and economic implications of the presence of brownfields, which makes them similar to researchers and members of the scientific community and to problem holders. Notwithstanding, their rationale behind putting emphasis on these latter categories might also be driven by an assumption that they need to consider these elements to convince actors necessary to approve their investment projects. Whatever motivation, it appears that all stakeholders, who deal with specific sites or are interested in a grounded approach to brownfield regeneration, require information on the local economic and social context. This unexpected finding elevates the importance of collecting and making available socio-economic information for site owners. This finding shows site owners' interest for issues related to the social pillar, supporting recent discussions about sustainable remediation.

If considered from the point of view of stakeholder concerns (Table 8), it emerges that those interested in the socio-economic conditions of brownfields (column 13 in Table 8) also have a high level of concern and attention with regard to health risks and housing abandonment, followed by environmental pollution and land consumption and by different forms of economic losses. A potential area for future research would thus be the specific content of environmental, social and economic risks, which site owners see as important in their work.

Authorities are mostly interested in information pertaining to investigation and strategic planning, followed by risk assessment and remediation strategies and options (see Table 7 and Figure 16). One would expect strategic planning to be of pivotal interest also for authorities, but instead it appears to be chosen mostly by site owners and problem holders.

If strategic planning is considered in relation with stakeholder concerns (Table 8), it emerges that stakeholders interested in planning issues are highly concerned first for loss of property value, and then for environmental pollution and health risks.

The interest of authorities in risk assessment can be explained by the fact that authorities are usually responsible to protect the general public from perils and therefore to affect and supervise measures of hazard defence, hence the results of risk assessment usually identify the need to intervene to determine an acceptable level of contamination. The choice of the more technical information on strategies and options for remediation might be interpreted in line with this remediation focus, where authorities can also determine remediation technologies. Nevertheless, it could perhaps also be linked to the professional interests of individual respondents who work as authorities. Future research could perhaps elucidate if there are differences between the countries involved. Based on preliminary interviews in Romania, it appears that Romanian authorities are eager to learn about remediation options, perhaps because this information is largely missing in the Romanian public sector.

Apart from sharing in the general interest for strategic planning, *problem holders* were interested in information on funding and financing, on the same par with site owners. They were also interested in investigation, socio-economic assessment and remediation strategies and options. As the problem holders group might bring together quite varied interests, such as those of organised public interest groups and of individual site neighbours, it would be worthwhile to investigate if there are distinct profiles of information-seekers to be identified.

Service providers stand out through their high interest in investigation, on a comparable level with authorities. If considered from the point of view of brownfield concerns (Table 8), investigation seems to be relevant for all those who attach a high score to the problem of losing property value. This result can indicate

that these individuals are aware of the need for sound investigation measures to generate knowledge and reduce uncertainties about the site status, thus reducing the risks that impact the market value of a property (Bartke, 2011). As further evidence for the investigation – economic value relationships, those who are concerned about keeping out potential investors (row 8 in Table 8) or about economic losses for the community (row 9 in Table 8), are also likely to choose investigation as a category of interest. However, investigation is quite relevant for other concerns, apart from those related to economic value (e.g. environmental pollution, health risks, and consumption). Those highly concerned about environmental pollution or health risks also selected investigation as a primary category of interest. The specific aims that stakeholders might have in relation to investigation may be worth further exploration. A notable absence for the service providers is the category of remediation strategies and options, which is absent from the top five choices of relevant categories within this group. However, the category remediation technologies evaluation and selection, which represents the operative step after remediation strategies and options, is in fifth position.

Finally, the *scientific community* seems to be mostly interested in remediation strategies and options. This may seem counter-intuitive to those equating science with research lacking practical value. Apart from the already noted interest in socio-economic assessments, it is worth pointing out the limited interests of researchers among our respondents in the area of investigation. This might be due to the fact that investigation strategies are relatively well established. On the other hand, scientists appear to be the only ones interested in decision-making and communication. If this finding is linked to the high interest in socio-economic assessments, it is possible to hypothesise that researchers have developed a strong interest for the involvement of stakeholders in regeneration processes – at least those researchers who participated in the questionnaire of this study (it could be argued that as a result of a self-selection process in all categories more of those stakeholders were ready to engage that have a higher propensity to participatory and trans-disciplinary processes). Future research could indicate if this finding is robust and, moreover, what would be the scientific reasons for striving for socially and economically relevant information. As anticipated in the discussion of Table 7, a possible hypotheses is that these preliminary findings suggest that the emerging interest for sustainability applied to regeneration and remediation represents an information need.

If the category remediation strategies and options is considered in relation with stakeholder concerns (Table 8), it emerges that those interested in this topic (column 6 in Table 8) also have concerns with regard, for example, to environmental pollution, health risks, and economic loss of the community, therefore to problems that remediation activities can possibly cause to the environment, society and economy.

It is also noteworthy that the information categories “Building and infrastructure documents”, “Deconstruction/re-use of structures and materials”, “Waste management”, “Requalification plan development”, and “Implementation, control, monitoring (land back to market)” are never ranked in the top five positions (see Table 7 and Figure 16). This is not to say that they were not of importance per se – however, they seem neither to be as critical nor as demanding to be dealt with when compared to the top rated categories.

CHAPTER 6 Information System for Brownfield Regeneration: from the identification of stakeholders' information needs and functional requirements to the provision of customised outputs

After the ISBR has been developed, as described in Chapter 4, it has been tested by stakeholders during the four involving activities described in paragraph 4.5. During these workshops, users have been invited: 1) to use the tool in order to feed the ANNs methodology; 2) to express their opinions on its usability to allow developers to improve functionalities; and 3) to test it in order to allow saving of information that could be of help to highlight the tool potentialities. In particular, it emerged that the tool, from the identification of information needs (as detailed in the next paragraph), "is able" to provide customised outputs according to users' requirements (as described in paragraph 6.2).

6.1 Supporting identification of stakeholders' information needs

As hypothesised in Section 1.1, and preliminary confirmed in Section 5.4, information needs can influenced by the roles stakeholders have, which means by the categories they belong to and by the commitments they have to fulfil.

According to findings reported in Chapter 5, stakeholders dealing with brownfield regeneration can belong to the following categories: site owners, site neighbours, local authorities, region and sub-regional government, regional and national regulators, local community groups, public interest groups, developer/investors, technology providers, consultants, financiers, contractors, insurers, end-users, media, and scientific community and research. These categories can be grouped as follows: authorities, problem holders, scientific community and researchers, services providers, and site owners. In the same chapter, a preliminary and preparatory attempt to identify stakeholders' information needs was done by means of an on-line questionnaire, where participants were invited to select the most relevant information categories (as depicted in Figure 8). Preliminary findings on similarities between some groups of stakeholders on information needs have been noticed.

However, the four workshops to test the ISBR brought to a more detailed overview of brownfield stakeholders' information needs. Information needs are related with the working activities stakeholders would like to improve using the ISBR and can be defined by means of search aims. Moreover, in order to respond to a specific information need, a set of information is needed, which can be classified according to the system of information categories depicted in Figure 8. With the aim of identifying suitable search aims and information categories that can provide the needed information, during the first two workshops stakeholders have been invited to manually write, for each session, a search aim and to select the related information categories from the system depicted in Figure 8.

After the search aims collected during Berlin and Brno workshops have been analysed and formalised into a list of 21 possible options (as listed in Table 9), they have been submitted to Romanian and Polish stakeholders during their tests on the tool, in the two last workshops respectively in Bucharest and Katowice.

Table 9 and Table 10 support in identifying stakeholders' information needs showing respectively the most common search aims and the most common information categories selected from the "system of information categories for brownfield regeneration" by groups of stakeholders involved in the testing of the ISBR.

Table 9 shows that, in general, the most common search aim is "Remediation" (in red), followed by "Best practices and successful case studies of BF regeneration" (in orange) and by "Land regeneration / Sustainable BF regeneration" (in yellow). This demonstrates the need for technical information on remediation as well as the need for benchmarking information and for information on wider issues like sustainability applied to

brownfield regeneration. A possible explanation of these dominant choices is that most of stakeholders involved in testing the tool are from Czech Republic, Poland and Romania, which represent emerging markets in brownfield management. Therefore, technical and benchmarking information on brownfield management can be beneficial to design successful and customised regeneration strategies. Information on sustainability applied to brownfield regeneration and land management reflects instead an interest that in recent years emerged on these issues among the scientific community, researchers and services providers and that has been confirmed by stakeholders involved in the workshop carried out in Katowice that have been specifically asked to provide feedbacks on this by means of questionnaires.

Table 10 shows that the most selected information category is, interestingly, “Strategic planning” (in red), followed by “Remediation strategies and options” (in orange) and “Investigation (preliminary/detailed)” (in yellow). This confirms the interest for remediation related aspects, as anticipated by the analysis on selected search aims, and it also suggests the importance of information that offers guidance on how to contextualise remediation itself in regeneration wide planning. This trend is basically followed by the different stakeholders’ groups, which show however interest also for “Remediation technologies evaluation and selection” (Problem holders, Services providers, Site owners), “Risk assessment (qualitative/quantitative)” (Scientific community and researcher, Services providers, Site owners), “Building and infrastructure documents” (Site owners) and “Deconstruction/re-use of structures materials” (Site owners).

Table 9 Most common search aims for groups of stakeholders.

		SEARCH AIMS																					Total
		Land regeneration / Sustainable BF regeneration	Best practices and successful case studies of BF regeneration	BF database (lists of BFs with related data, e.g. localization, area, typology, former/historical utilization, contamination, limitations in use, etc.)	BFs regeneration barriers	BFs with the highest redevelopment potential	Characterization of soil and groundwater	Ecological issues related to BF management (e.g., presence of biotope, type of biotope, value of biotope, protected species, red-list species)	Economic benefits of BFs	Funds for BF regeneration	Monitoring	National strategies and guidelines for BF regeneration	Planning (land use information, regional/urban land use plans)	Remediation	Residential redevelopment of BFs	Reuse of building rubble	Risk assessment	Rural redevelopment of BFs	Social benefits and impacts of BFs	Stakeholders analysis	The adoption of Public Private Partnership strategies in BF management	Waste management and control	
GROUPS OF STAKEHOLDERS	Authorities	10	29	13	16	12	16	1	13	16	14	19	8	21	10	7	12	7	21	10	8	8	**271**
	Problem holders	11	14	4	10	2	6	1	3	10	4	6	3	11	5	2	8		4	3	3	3	**113**
	Scientific community and researchers	34	21	9	14	15	21	2	10	9	22	30	18	46	13	13	20	9	17	13	8	10	**354**
	Services providers	14	16	4	12	9	25	1	13	7	9	15	5	20	9	6	17	5	15	11	7	8	**228**
	Site owners	5	6	1	4	1	3	1	3	3	3	3	4	7	4	1	3		5	3	3	4	**67**
Total		**74**	**86**	**31**	**56**	**39**	**71**	**6**	**42**	**45**	**52**	**73**	**38**	**105**	**41**	**29**	**60**	**21**	**62**	**40**	**29**	**33**	**1033**

Table 10 Most common information categories for groups of stakeholders.

		INFORMATION CATEGORIES													
		Building and infrastructure documents	Decision-making and communication	Deconstruction/re-use of structures materials	Funding and financing	Implementation, control, monitoring (land back to market)	Investigation (preliminary/detailed)	Remediation strategies and options	Remediation technologies evaluation and selection	Requalification plan development	Risk assessment (qualitative/ quantitative)	Socio-economic assessment	Strategic planning	Waste management	Total
GROUPS OF STAKEHOLDERS	Authorities	49	46	29	42	35	64	58	50	39	52	41	67	34	606
	Problem holders	27	17	16	16	11	23	31	28	18	26	12	39	13	277
	Scientific community and researcher	67	66	58	55	66	88	96	95	77	98	58	100	75	999
	Services providers	20	18	18	20	20	37	45	37	19	31	18	45	20	348
	Site owners	11	5	9	6	5	9	15	9	5	9	2	15	5	105
Total		**174**	**152**	**130**	**139**	**137**	**221**	**245**	**219**	**158**	**216**	**131**	**266**	**147**	**2335**

In order to better understand stakeholders' information needs, the assessment of countries-related similarities and differences has been performed. Since the language is, to some extent, a good indication of the country where stakeholders act, this information has been considered relevant for the purposes of the research and has been assessed. Indeed, when stakeholders register into the tool, they are invited to indicate their preferred language. Accordingly, Table 11 reports the number of selected search aims sorted on the basis of the preferred language, as indication of their geographic context.

Table 11. Number of time that search aims have been selected according to the preferred language as indication of stakeholders' geographic context. The three most common search aims are reported in bold.

		PREFERRED LANGUAGES/GEOGRAPHIC CONTEXT								
		Czech	English	German	Italian	Polish	Romanian	French	Spanish	Total
SEARCH AIMS	Land regeneration / Sustainable BF regeneration		**27**	6		2	5	6	2	48
	Best practices and successful case studies of BF regeneration	15	**26**	1		3	9	4	1	59
	BF database (lists of BFs with related data, e.g. localization, area, typology, former/historical utilization, contamination, etc.)	**23**		2			1			26
	BFs regeneration barriers	6	14		1	2	5	4	1	33
	BFs with the highest redevelopment potential		8		4	2	10	4	1	29
	Characterization of soil and groundwater		13	9		2	5	5	3	37
	Ecological issues related to BF management (e.g., presence of biotope, type of biotope, value of biotope, protected species, red	1		2						3
	Economic benefits of BFs		13	3			5	4	1	26
	Funds for BF regeneration	8	7				6	4	1	26
	Monitoring		10	3		7	10	4	1	35
	National strategies and guidelines for BF regeneration	2	19	3		2	13	5	2	46
	Planning (land use information, regional/urban land use plans)		14	2			5	4	1	26
	Remediation	7	18	8	4	4	14	15	3	73
	Residential redevelopment of BFs	6	8			1	5	4	1	25
	Reuse of building rubble		4		1	1	10	4	1	21
	Risk assessment		14	1	1	2	7	9	2	36
	Rural redevelopment of BFs		5	1			5	6		17
	Social benefits and impacts of BFs		19	9		1	6	4	1	40
	Stakeholders analysis		11			1	6	4	1	23
	The adoption of Public Private Partnership strategies in BF management		7				5	4	1	17
	Waste management and control		6	1		1	5	4	2	19
Total		**68**	**243**	**51**	**11**	**31**	**137**	**98**	**26**	**665**

Table 11 shows that the most common preferred language is English even though all stakeholders that tested the tool and most of users are not Anglophone. A possible explanation is that stakeholders primarily use the tool to find information developed by international projects, initiatives or groups. Consequently, for the English language, it is not possible to state a direct link between the language and the country, while this is recognised for the other languages. Therefore, the most represented countries are Romania, France and Czech Republic. Stakeholders from Romania showed a particular interest for "Remediation", "National strategies and guidelines for BF regeneration", "BFs with the highest redevelopment potential" and other technical aspects related to regeneration. These choices reflect the need, for this new market in brownfield regeneration, for freely available information on technical aspects as well as for information that can offer guidance on strategic and planning issues. Stakeholders from France showed a quite homogeneous

distribution of interest around the two most clicked search aims, which are “Remediation” and “Risk assessment”. Czech stakeholders searched for information especially on “BF database (lists of BFs with related data, e.g. localization, area, typology, former/historical utilization, contamination, etc.)”, which is also the search aim that received more clicks, besides the first two for the English context (i.e. “Land regeneration / Sustainable BF regeneration” and “Best practices and successful case studies of BF regeneration”).

This analysis can be widened, considering also the information categories sorted by language (Table AIV1 in ANNEX IV), and deepened, since the ISBR allows to identify the connections between specific search aims and related information categories. In ANNEX V, three examples are reported to elucidate this potentiality of the tool. These refer to the three most clicked search aims sorted by language, as mentioned at the end of the previous paragraph. Accordingly, from Table AV1 it is possible to see that for “Land regeneration / Sustainable BF regeneration” in English the three most selected information categories are “Strategic planning”, “Risk assessment (qualitative/quantitative)” and “Requalification plan development”: the first and the third are very in line with the typology of search aim, which is large-scale effort-related, while the second choice, more technical, could reflect the common understanding that regeneration is risk-based, therefore information on risk assessment is of paramount importance. For “Best practices and successful case studies of BF regeneration” in English the most selected information categories are “Investigation (preliminary/detailed)” and “Remediation technologies evaluation and selection” both as first choices, then “Strategic planning” and, as third, “Risk assessment (qualitative/quantitative)”. These selections show that best practices and successful case studies, as a sort of benchmarking information to compare the quality of other regeneration activities, are mostly needed by stakeholders that aim to improve technical aspects of their regeneration projects and works. Finally, for “BF database (lists of BFs with related data, e.g. localization, area, typology, former/historical utilization, contamination, etc.)” in Czech, the first most selected information category is visibly “Strategic planning”, followed by “Investigation (preliminary/detailed)”, and by “Building and infrastructure documents” and “Decision-making and communication”, these last two both in third position. These choices point out the urgent need of Czech stakeholders for brownfield inventories, which can offer support to decision-makers in strategic planning as well as guidance to professionals in consulting.

6.2 Supporting stakeholders in finding needed information and providing functionalities according to their requirements

6.2.1 Supporting stakeholders in finding needed information according to their requirements

An ad hoc set of indicators has been adopted to demonstrate that the ISBR allows answering to stakeholders’ information needs. These indicators have been developed on the basis of the available web-links evaluations stored into the tool, according to the ANN inputs “scores” (i.e. pertinence, appropriateness, usefulness, clarity, reliability and accuracy, and updating), as defined in Section 4.3.

This set comprehends the following four indicators: 1) percentage of web-links evaluated as appropriate for each category of concern on the total number of web-links evaluated for that specific category. This indicator allows to understand the level of appropriate information the tool is able to provide. 2) Percentage of web-links with rating (weighted average of the scores according to usefulness, clarity, reliability and accuracy, and updating) ≥ 4 on the total number of web-links evaluated as appropriate for that specific information category. This indicator allows to visualise the level of satisfaction of users for the information provided. 3) Percentage of web-links evaluated as pertinent for a specific search aim sorted by groups of stakeholders.

This indicator allows to understand the level of compliance of the tool to particular search aims. 4) Mean of evaluations in time. This indicator allows to visualise the performance of the ISBR in time. Results according to indicators 1 and 2 are reported in Table 12 (and respectively in Column 6 and 8). Results on the pertinence of web-links to search aims, according to indicator 3, are reported in Table 13; while the visualisation of the mean of evaluations in time (Indicator 4) is reported Figure 17.

Table 12 Analysis of information provided by the tool with a focus on level of appropriate information and level of satisfaction of users, based on web-links stored, accessed and evaluated by users.

Information category	**Total nr. of web-links**	**Nr. of web-links accessed**	**Nr. of web-links evaluated**	**Nr. of web-links evaluated as appropriate**	***Indicator 1*** **Percentage of web-links evaluated as appropriate for each category of concern on the total number of web-links evaluated for that specific category**	**Web-links with rating ≥ 4**	***Indicator 2*** **Percentage of web-links with rating ≥ 4 on the total number of web-links evaluated as appropriate for that specific information category**
Building and infrastructure documents	11	11	7	2	29%	1	50%
Decision-making and communication	59	41	19	19	100%	13	68%
Deconstruction/re-use of structures materials	29	21	13	10	77%	8	80%
Funding and financing	18	14	9	8	89%	6	75%
Implementation, control, monitoring (land back to market)	28	10	4	3	75%	0	0%
Investigation (preliminary/detailed)	103	92	11	9	82%	8	89%
Remediation strategies and options	115	77	57	40	70%	29	73%
Remediation technologies evaluation and selection	65	45	38	27	71%	20	74%
Requalification plan development	38	12	8	6	75%	3	50%
Risk assessment (qualitative/quantitative)	88	41	18	13	72%	9	69%
Socio-economic assessment	33	13	6	5	83%	2	40%
Strategic planning	121	57	31	25	81%	19	76%
Waste management	44	19	18	12	67%	8	67%
Total	752	453	239	179	75%	126	70%

According to Table 10, “Strategic Planning”, “Remediation strategies and options” and “Investigation” are the three most clicked information categories. Table 12 shows that these categories are also the ones with the highest number of web-links in general. As far as numbers of evaluated web-links are concerned, it is possible to notice a lowering for “Investigation”, while an increment for another category: “Remediation technologies evaluation and selection”.

“Remediation strategies and options”, “Remediation technologies evaluation and selection”, and “Strategic Planning” present the highest numbers of evaluated web-links, of web-links evaluated as appropriate and of web-links with evaluations ≥ 4, which represent quite satisfactory percentages.

Considering the overall evaluations, web-links are generally considered appropriate for the selected information categories, and most of them have good percentages of evaluations ≥ 4: this shows a good level

of satisfaction of users, which means that the tool is supporting stakeholders in providing good quality information.

Few exceptions can be identified (e.g. Socio-economic assessment, Building and infrastructure documents, Requalification plan development) that are due to low numbers of evaluated web-links.

Table 13 Percentage of web-links evaluated as pertinent by groups of stakeholders according to their search aims.

Stakeholder Group	**Number of links evaluated as pertinent by the specific stakeholder group**	**Total number of links evaluated by the specific stakeholder group**	**% Pertinent**
Authorities	66	89	74%
Problem holders	49	63	78%
Scientific community and researchers	85	146	58%
Services providers	58	89	65%
Site owners	23	28	82%
All stakeholder groups			74%

Table 13 shows that, in general, all stakeholder groups can find information that is pertinent with their search aims. Some stakeholder groups show a quite high level of satisfaction ("Authorities", "Problem holders" and mostly "Site owners") while "Scientific community and researchers" show a moderate level of satisfaction. This is probably due to the fact that the ISBR collects several technical and practical information, guidelines and regulations, which cannot always answer to academic queries. Therefore, even though 58% is still representing that the tool is able to provide information answering to search aims of "Scientific community and researchers", this result represents a possible area of improvement of the tool. As a consequence, the ISBR developers investigated how to better answer to the "Scientific community and researchers" information needs, and started collecting and making available to users information on sustainable regeneration and sustainable remediation, which recently emerged to be of interest, as anticipated in paragraph 1.

Finally, in order to describe the general performance of the ISBR in terms of trend of evaluations received by web-links, the indicator "mean of evaluations in time" has been considered for graphic representation (see Figure 17).

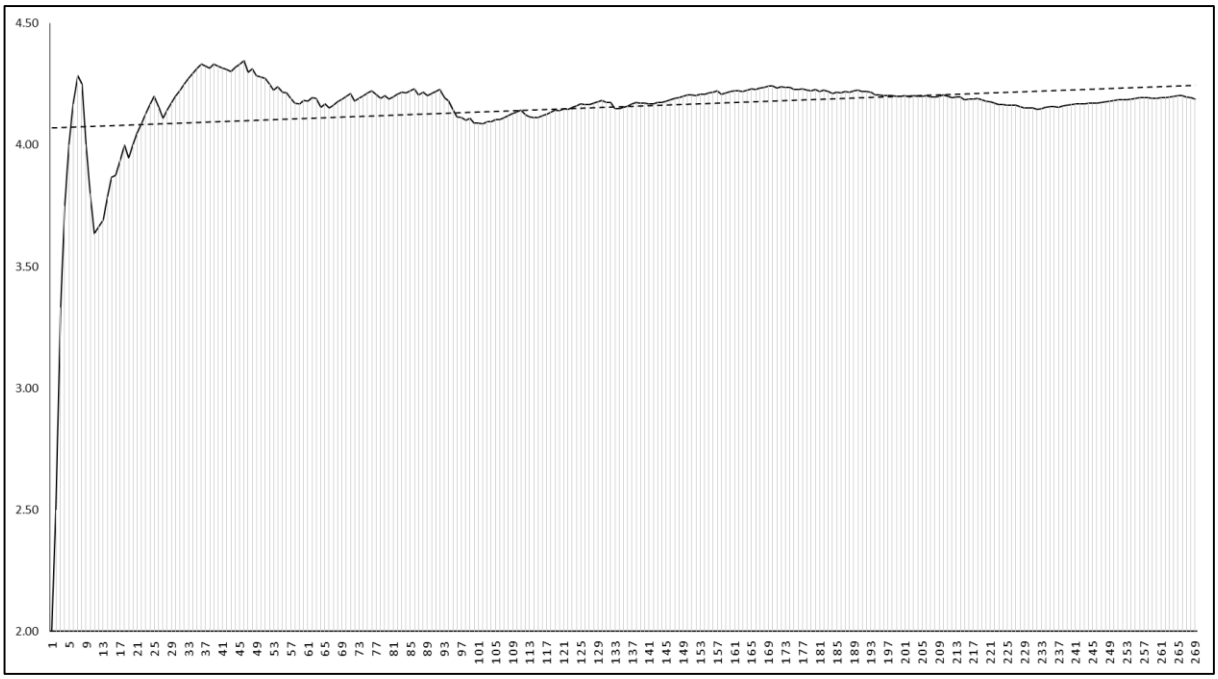

Figure 17 Mean of evaluations in time. On the "x" axis the number of evaluations received by appropriate web-links in time is reported, and on the "y" axis the mean of web-links ratings in time is reported. (*The total number of evaluations received by appropriate web-links in time is higher than in Table 12 because, here, also evaluations received by new web-links during the uploads are counted).*

Figure 17 reports on the "x" axis the number of evaluations received by appropriate web-links in time and on the "y" axis the mean of ratings in time. The graph represents how the mean of evaluations evolves in time. It shows that the trend of evaluations quickly achieved a good level of satisfaction (≥ 4), reflecting the initial good quality of documents/information uploaded in the system by experts and stakeholders. Moreover, the tool improved its performance along its use receiving better evaluations in time. This is reflecting the expected behaviour of the implemented ANN, which improves its results by continuously "learning" from the selections and evaluations of users. In fact, one characteristic of on-line ANN is that it continuously updates its weights set in order to improve results. This yields to a general improvement in results characterised by fluctuations mostly due to incoherent evaluations from users, which is normal in a community where people can think differently from each other or can change their opinion in time.

6.2.2 Supporting stakeholders with functionalities according to their requirements

Overall, the tool testing activities carried out with Czech, German, Polish and Romanian stakeholders brought to develop and improve some functionalities of the ISBR according to specific recommendations they provided during discussions and filling out questionnaires. Some examples of functionalities that have been expressly developed and improved according to users' indications are: 1) "Link Control Panel" functionality; 2) "Definition of the search aim"; 3) "Procedure to become an expert user"; and 4) "Sustainability information filter".

The functionality "Links Control Panel" allows users to check if the web-links they inserted into the tool are updated and working properly, in order to prevent problems related to the fact that web-links can expire after some time.

The functionality "Definition of the search aim" allows users to select, for each session, their search aim from a list of possible options. This list is the result of search aims that stakeholders involved in the Berlin and Brno

workshops manually wrote and that the tool developers elaborated and formalised into a list of possible options (see list in Table 9).

The “Expert users” functionality allows experienced users to modify or to delete web-links that refer to out-dated information. This way the information into the tool can be monitored and managed not only by the administrator, but also by users that are expert in brownfield regeneration and aware of changes in information related to their own context.

The “Sustainability information filter” allows users to select web-links that specifically focus on sustainable brownfield regeneration and sustainable remediation, answering a need of the group “Scientific community and researchers” (see discussion of Table 7, 7th paragraph of Section 5.4.2, and paragraph 1). This information need has actually been confirmed during the Katowice workshop in which occasion stakeholders, when asked about their opinion on availability on information related to sustainability into the tool, clearly demonstrated their interest with 11 positive answers on 12 participants (one participant did not provide any answer). Now stakeholders can exploit the ad hoc implemented functionality, in the main ISBR interface, simply clicking on the icon representing sustainability (i.e. the three overlapping circles that symbolise the three sustainability pillars). The provision of this functionality represents a way to make the tool more respondent the information needs of “Scientific community and researchers” group.

Finally, as far as questionnaire surveys on overall level of satisfaction on the tool are concerned, collected data, from questionnaires submitted at the end of workshops, show that on 47 filled out questionnaires, 36 (almost 77%) demonstrate that the ISBR allowed stakeholders to find information to answer to their information needs.

CHAPTER 7 Conclusions

The work described the adoption of a participatory methodology to test the hypothesis that roles and categories of stakeholders, once identified, can apply to different geographic contexts; while perceptions, concerns, attitudes and information needs can possibly change depending to the context where stakeholders act and to the categories they belong to. Based on the understanding gained from the preliminary involving activities, the ISBR has been developed and tested to obtain further feedbacks from potential users and to corroborate the first findings on information needs. The strength of the developed tool is given by the methodology it is based upon, which makes use of ANNs and which allows to more deeply understand stakeholders' information needs and to answer them providing customised information. All this to overcome the barriers that hamper effective availability and sharing of useful information among practitioners in sustainable brownfield regeneration and to enhance informed and successful decision-making processes.

The conducted literature review confirmed that stakeholder involvement is widely recognised by the scientific community as a beneficial factor for the achievement of sustainable brownfield regeneration. Indeed, stakeholder involvement can contribute during the appraisal process to identify more sustainable regeneration options. Moreover, through systematic engagement, ensuring that all groups are addressed and are given the opportunity to participate, the acceptance of the decision-making process can be increased amongst these parties whose opposition could otherwise interfere with a regeneration project. This is also recognised by those initiatives and forums developing sustainable approaches to brownfield regeneration and remediation, which show a high level of consensus in the shared sustainability underpinning principles and which encourage to take into proper consideration, as well as the three pillars of sustainability, effective stakeholder involvement.

Furthermore, stakeholder engagement can also be used by researchers to design and deliver, as this is the case of the present thesis, suitable and customised tools. The research activities, carried out involving different groups of stakeholders from Czech Republic, Germany, Italy, Poland and Romania, brought to a series of outcomes, as wrapped-up in the following.

As a result of a fruitful discussion with the TIMBRE partners and International Advisory Board, it appeared to be clear that, in general, stakeholders dealing with brownfield regeneration can belong to one or more of the following categories: site owners, site neighbours, local authorities, region and sub-regional government, regional and national regulators, local community groups, public interest groups, developer/investors, technology providers, consultants, financiers, contractors, insurers, end-users, media, and scientific community and research. These categories can be grouped in authorities, problem holders, scientific community and researchers, services providers, and site owners.

One of the main findings is that, as far as the range of information needs is concerned, the consulted stakeholders have settled on a number of 13 information categories, which means that this is the range of information that they deem appropriate and inclusive to address all aspects that the complexity of regeneration projects can present.

Perceptions of stakeholders involved proved to be different according to the country, thus confirming the research hypothesis. Indeed, German and Italian stakeholders perceive brownfields as complex systems, where several issues need to be addressed, while Romanian stakeholders consider contamination as almost the only issue to be addressed; and Czech and Polish stakeholders address an intermediate number of issues. Attitudes and concerns seemed, instead, to be quite similar between countries. As far as preliminary information needs are concerned, some similarities and differences between groups of stakeholders have

been noticed, however, outstanding outcomes emerged from the scientific community and research group, which showed a punctual interest for remediation strategies and options and socio-economic aspects: this seemed they could likely benefit from information on the remediation options appraisal process as well as on the way to integrate the three sustainability pillars, which represent the main issues addressed by sustainable remediation.

Data stored during tests on the ISBR allowed to better understand stakeholders' information needs, and to identify and analyse relations between search aims and related information categories. Even though the collection and analysis of stakeholders' feedbacks represent a first attempt to systematically study potential users' needs, some results allowed identifying some trends in stakeholders' information requirements as well as different patterns of behaviours depending on the roles stakeholders play and the context where the information need to be applied, confirming the research hypothesis and drawing a clearer picture of what their information needs could be.

Overall, stakeholder groups showed to be concerned first on remediation aspects, then on benchmarking information, which represent valuable information for practitioners to compare and improve their work in the complex field of brownfield regeneration, and then on the relatively new issue of sustainability applied to brownfield regeneration and remediation. This last point confirms an interest that already emerged in the preliminary engaging stage among the scientific community and researchers. However, as far as the overall interest for remediation aspects is concerned, it is possible to notice a discrepancy from preliminary data collated by means of the questionnaire, where remediation-related aspects were not ranked in the first positions. This represents an interesting behaviour of stakeholders that participated to involving activities: indeed, they seem to demonstrate some interests in the questionnaire, but what their practical interests really are emerge during the usage of the tool. This could represent an area of future investigation, in order to better understand which involving methodologies are more effective to obtain reliable information from stakeholders.

As far as the geographic context where stakeholders act is concerned, particular trends have been identified, and, based on them, some hypothesis for future research have been formulated. Mature markets confirmed their interest for remediation-related aspects, highlighting the central role that risk assessment plays in the process: this could reflect the common understanding that regeneration, when including land contamination problems, is risk-based; therefore information availability on risk assessment is of crucial importance.

Emerging markets showed to seek information and tools to assist them mostly in strategic and planning issues, like brownfield inventories, georeferenced data sets and prioritisation tools. This demonstrates that these markets, even if relatively new, are aware of the importance that the first regeneration phases play in large-scale effort-related projects, as well as of the importance that geo-referenced and steering information play in setting-up informed, strategic and effective regeneration plans. Datasets and georeferenced information can indeed support during the risk assessment phase and in particular in the development of the preliminary conceptual site model, which is fundamental in the first stages of the remediation process.

Overall, the ISBR has proved to be able to answer to stakeholders' information needs and this is linked with the potentialities of the developed ANN methodology. Main benefits of using an ANN proved to be its ability to deal with lack of information and its continuous learning/updating, which is able to dynamically reflect changes in user's preferences trends.

Without the analysis of stakeholders' information needs, it would be difficult to visualise the improvements that deemed to be needed. The most explicit one, and feasible to be achieved at this stage, consisted in the

development of an ad hoc functionality to filter information specifically addressing sustainable regeneration or remediation, as it clearly emerged as information need of the scientific community group.

Taking into consideration the indications provided by the involved stakeholders, a further step ahead of this work is suggested to be an improved platform able to combine the ISBR functionalities already present with geo-referenced functionalities and datasets. This could offer support to emerging as well as to mature markets providing customised and site-specific information and could become a win-win factor to improve informed dialogue among different stakeholders starting from the first phases of decision-making, in order to finally foster delivery of successful and sustainable regeneration solutions.

Information related to inventories and georeferenced datasets, even if appeared to be mostly needed by new regeneration markets, however, can be supposed to be highly needed also by some mature markets, which could find this type of information of great benefit for cost saving, for instance, during characterisation when a wealth of historical or hydrological data are needed. This hypothesis is formulated because in some mature markets, georeferenced datasets can be easily accessible (e.g. in UK, where private companies sell this type of information for very competitive prices), while in some other experienced markets, this type of information is not available and this represents a data gap. This is caused by a number of reasons like those related to know how protection, or to the fact that, in order to provide a wealth of georeferenced data at a country level, a significant investment should be done. Also, another barrier could be represented by the difficulty of guaranteeing high quality and validated data in order to make people responsible for remediation confident when presenting projects to competent authorities.

These represent reasons why additional research in this field is suggested: improving the ISBR platform, combining the set of functionalities already present with those ones suggested by stakeholders could indeed represent an economic benefit for developers as well as for users. This improved platform could grow the wealth of information needed by stakeholders and, along with additional dissemination activities, could increase accesses by users, allowing the ANNs outputs to be more and more refined.

Also, it has to be considered that the methodological developments of the research presented in this thesis have been directly applied, through engaging activities, to all stakeholder categories identified (except for insurers, since there were no available contact people for this category) and to five European countries, leading to a partial cross-EU overview of stakeholders' roles, perceptions, attitudes, concerns and information needs. This could be widened, in future research, considering more countries from Europe or even from outside Europe.

Finally, this work encourages and offers guidance to other research areas where understanding stakeholders' roles, characteristics and mostly information needs is of importance for provision of customised and site-specific information in complex decision-making processes, such as those related to real estate and major infrastructure projects, sustainable urban development, logistics management, renewables deployment and acceptance, or to integrated coastal zone management.

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ANNEX I - Brownfield regulatory environment in Europe

Table AI 1 Brownfield regulatory environment in Europe with references.

Brownfield related issue	**Policy**
AIR	Air Quality Framework Directive (96/62/EC) and its Daughter Directive
	Directive on National Emissions Ceilings (2001/81/EC)
	Directive on Large Combustion Plants (LCPD) (2001/80/EC)
CHEMICALS	Thematic strategy on the sustainable use of pesticides
	Directive on Biocidal Products (98/8/EC)62
	Directive 91/414/EEC on plant protection products
	Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals (2006/1907/EC)
	Regulation on classification, labelling and packaging of substances and mixtures (2008/1272/EC)
ENERGY AND RESOURCES	Directive on the on the promotion of the use of energy from renewable sources (2009/28/EC)
	Roadmap to a Resource Efficient Europe (COM(2011) 571)
ENVIRONMENTAL LIABILITY	Directive 2004/35/EC on environmental liability with regard to the prevention and remedying of environmental damage
FUNDS	Structural funds http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=structural_funds
	Guidelines for state-aid http://europa.eu/legislation_summaries/competition/state_aid/index_en.htm
HEALTH AND SAFETY	Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work (OSH Framework Directive)
IMPACT ASSESSMENT	Environmental Impact Assessment Directive (85/337/EEC amended in 1997 and 2003)
	Strategic Environmental Assessment Directive (SEA) (2001/42/EC)
INDUSTRIAL EMISSIONS	Directive on Integrated Pollution Prevention and Control (96/61/EC
	Integrated Pollution Prevention and Control Directive (2008/1/EC)
	Industrial Emissions Directive (IED) (2010/75/EU)
NATURE AND HABITATS	Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora
	Directive 2009/147/EC on the conservation of wild birds
SOIL	The proposal for a Soil Framework Directive – withdrawal http://ec.europa.eu/environment/soil/process_en.htm
URBAN ENVIRONMENTS	Thematic Strategy on the Urban Environment (adopted by the Commission on 11 January 2006) http://ec.europa.eu/environment/urban/thematic_strategy.htm

WASTE	Waste Framework Directive (2006/12/EC, codified version Directive 75/442/EEC, as amended)
	Directive 91/689/EEC on Hazardous Waste, amended in 1991
	Directive on the Disposal of Waste Oils (75/439/EEC amended in 2000
	Landfill Directive (1999/31/EC)
	Sewage Sludge Directive (86/278/EEC)
	Directive2006/21/EC on the management of waste from the extractive industries
	Thematic Strategy on the prevention and recycling of waste http://ec.europa.eu/environment/waste/strategy.htm
WATER	Water Framework Directive (2000/60/EC) and Groundwater Directive (2006/118/EC)
	Nitrates Directive (91/676/EEC)
	Urban Wastewater Treatment Directive (91/271/EEC)
	Bathing Water Directive (2006/7/EC)

ANNEX II - Sustainable remediation definitions and principles

Definitions

Common Forum - "Sustainable Remediation of soil, sediment and groundwater involves the assessment and management of significant risks to human health and the environment, in a manner that identifies the environmental, social and economic benefits and impacts of remedial strategies and options, and which seeks to maximise the overall benefit through a balanced, evidence-based and transparent decision-making process" (Common Forum and NICOLE, 2013).

NICOLE - "A sustainable remediation project is one which the stakeholders agree represents the best solution considering environmental, social and economic factors" (NICOLE, 2010).
"Sustainable Remediation of soil, sediment and groundwater involves the assessment and management of significant risks to human health and the environment, in a manner that identifies the environmental, social and economic benefits and impacts of remedial strategies and options, and which seeks to maximise the overall benefit through a balanced, evidence-based and transparent decision-making process" (Common Forum and NICOLE, 2013).

SuRF-Italy - "The process for remediation and management of contaminated sites, aimed at identifying the best solution when considering environmental, social and economic factors, through a balanced decision process, agreed by stakeholders" (SuRF-Italy, 2014).

SuRF-UK - "Sustainable remediation: the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process" (SuRF-UK, 2010).

ITRC - "Sustainable remediation refers to an integrated assessment of the environmental, economic, and social impacts of remedial activities" (ITRC, 2011b).

SURF - "Sustainable remediation can be defined as a remedy or combination of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources" (SURF, 2009).

SuRF-Canada - "Sustainable remediation considers the environmental, social and economic impacts of a project to ensure an optimal outcome, while being protective of human and environmental health, both at a local level and for the larger community" (SuRF-Canada, 2012).

SuRF-ANZ - "Sustainable Remediation can be defined as a remediation solution selected through the use of a balanced decision making process that demonstrates, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than any adverse effects" (SuRF-ANZ, 2011).

ASTM – The guide aims to provide a "framework that helps the user identify and incorporate sustainable best management practices (BMPs) into site cleanup (which includes assessment and remediation), and

enables the user to perform measurement of BMPs during the cleanup process" (ASTM, 2013) (This is not exactly a definition, but it is reported for completeness).

ISO - "Sustainable remediation seeks to eliminate and/or control unacceptable risks in a safe and timely manner, whilst maximising the overall environmental, social and economic benefits of the remediation work" (ISO, Work in progress).

Principles

Common Forum, together with NICOLE (2013), recognises that sustainable remediation principles embody:

- the importance of contributing to sustainable development, for example, more sustainable use of natural resources or the EU global climate change and energy targets;
- conviction that decision-making based on sustainability principles can lead to: a more efficient use of environmental, social and economic resources; better remediation solutions balancing impacts and effects of different remediation measures, and; enhanced land management for the long term.

NICOLE, beside the principles shared with Common Forum (2013), states five key principles (NICOLE, 2012):

- importance of communication and building trust between stakeholders;
- Risk Based Land Management and synergy with sustainable remediation;
- Experience in the use of socio-economic factors;
- Importance of appropriate way to measure sustainability to demonstrate practical delivery of sustainability to stakeholders;
- Bottom-up approach to promote sustainable remediation in Europe and sharing of experiences through case studies.

SuRF-Italy explicitly refers to SuRF-UK to identify its key principles (White paper, 2014).

SuRF-UK identifies the following principles that are associated with sustainable remediation (SuRF-UK, 2010):

- Protection of human health and the environment;
- Safe working practices (for workers & local communities);
- Consistent, clear and reproducible decision-making;
- Record keeping and transparent reporting (including assumptions & uncertainties);
- Good governance and stakeholder involvement;
- Sound science.

For **ITRC** protection of human health and the environment is still of paramount importance, as well as complying with federal, state, and local regulations; however, GSR principles factor into consideration a range of environmental issues and community impacts aimed at maximizing the environmental, social, and economic considerations as appropriate (ITRC, 2011), attempting to bridge US Green Remediation concepts with the sustainable remediation concepts emerging from SURF.
Under some clean-up authorities, this approach may involve consideration of economic aspects with ecological and social benefits in the decision making process.

To accomplish sustainable remediation, **SURF** embraces sustainable approaches to remediation that provide a net benefit to the environment. To the extent possible, these approaches:

- minimize or eliminate energy consumption or the consumption of other natural resources;
- reduce or eliminate releases to the environment, especially to the air;
- harness or mimic a natural process;
- result in the reuse or recycling of land or otherwise undesirable materials; and/or

- encourage the use of remedial technologies that permanently destroy contaminants.

Considering their nature, the above reported approaches can be considered as principles.

SuRF-ANZ identifies the following principles that are associated with sustainable remediation (SuRF-ANZ, 2011):

- Protection of human health and the environment;
- Safe working practices (for workers & local communities);
- Consistent, clear and reproducible decision-making;
- Record keeping and transparent reporting (including assumptions & uncertainties);
- Good governance and stakeholder involvement;
- Sound science.

Note: these principles are based on SuRF-UK (2010).

ASTM states that "the environmental portions of the guide align with the Greener Cleanup Principles released by USEPA in August 2009" (ASTM, 2013).

ISO - "Key principles need to be met during decision making and implementation in order to still say in the end that the remediation is as sustainable as it can be given the goals, boundaries, political aspects, the requirements for current and future land use. The following key principles can be defined and must be adhered to:

- The legal requirements for the remediation are met
- No unacceptable risks (health and safety) for humans
- No unacceptable effects on the surrounding area
- Transparent decision making process based on sound knowledge
- Engagement with all relevant stakeholders" (ISO, Work in progress).

ANNEX III - Information Categories (Rizzo et al., 2015)

Strategic planning: legal requirements, regional/urban land use plans as well as the interests of local government, zoning boards, planning agencies and environmental regulatory agencies are identified in order to ensure that all the plans requisites and restrictions are respected and to foster the success of the rehabilitation process. In this contest the identification and involvement of the relevant stakeholders is a key point since it ensures that their needs, visions for the area and interests are properly analysed and taken into consideration.

Investigation (preliminary/detailed): determination of site characteristics and definition of the extent and magnitude of contamination at a site.

Preliminary investigation concerns the identification of potential contamination according to information on of site history (i.e. maps, plans, photographs, geological and hydrological data, past owners/occupiers, industrial or commercial uses, raw materials, disposal of waste and any mining activities) and available sampling data.

Detailed investigation focuses on confirming whether any contamination exists at a site, locating any contamination, characterizing the nature and extent of that contamination as well as defining the conceptual model of the site. It is essential to perform an appropriately detailed study of the site in order to identify the cause, nature, and extent of contamination and the possible threats to the environment or to any people living or working nearby.

Risk assessment (qualitative/quantitative): qualitative risk assessment allows the quick identification of potential risks, as well as assets and resources which are vulnerable to these risks. Qualitative risk assessment deals with the comparison of contaminant concentrations measured in soil, water or soil gas at a site with generic assessment criteria. Generic assessment criteria are typically conservative to ensure that they are applicable to the majority of sites and normally apply to only a limited number of pollutant linkages.

Quantitative risk assessment makes greater use of site-specific data to conduct a more accurate assessment of risks. Quantitative/detailed risk assessment involves the use of models to derive site-specific assessment criteria that are then compared with measured concentrations in soil, water or soil gas at the site to estimate risk.

Remediation strategies and options: review and analysis of clean up alternatives. It is a preparatory stage to the "Remediation technologies selection" because it aims to collect available information on possible strategies and options including the capability to meet specific clean up and redevelopment objectives, in accordance with legal requirements and regional/local planning and development goals.

Remediation technologies evaluation and selection: permits the evaluation of various technologies in order to identify those technologies with the capability to meet specific clean-up and redevelopment objectives taking into account also the economic aspects (i.e. the most suitable remediation technologies for the specific site according to a specific budget). The review, analysis and selection of clean-up alternatives relies on the data collected during the site assessment, the investigation phases and the cost-benefit analysis.

Building and infrastructure documents: collection of documents for building planning, drawings and specifications needed to obtain building permits and to support the BF rehabilitation. These documents are used for tendering and to ensure that buildings are safe, healthy, accessible and sustainable from the environmental point of view.

Deconstruction/re-use of structures materials: deconstruction is the process of selectively and systematically disassembling buildings that would otherwise be demolished to generate a supply of materials suitable for reuse in the construction or rehabilitation of other structures.

Waste management: the collection, transport, processing or disposal, managing and monitoring of waste materials, mostly produced during the deconstruction of structures.

Requalification plan development: definition of a remediation technologies plan, which focuses on the application clean-up technologies to prepare the property for redevelopment and reuse. The design of the requalification plan and its implementation requires close coordination with all stakeholders.

Implementation, control, monitoring (land back to market): guarantee that the selected interventions are properly implemented, monitored and enforced in order to ensure the long-term durability, reliability and effectiveness of the interventions.

Socio-economic assessment: the socio-economic assessment aims at identifying the possible economic (business) implications of different alternatives for requalification of the site.

Funding and financing: the organization responsible for the remediation process has to consider several strategies in order to provide funding and financial support to all the other processes and phases.

Decision-making and communication: decision making is the process of evaluating and ranking different scenarios (i.e., suitable solutions for the rehabilitation of contaminated sites) on the basis of different criteria such as for example future land uses, socioeconomic benefits, remediation costs, time span, environmental impacts, technology set/s (including train technologies) and residual risk. These aspects are usually evaluated by means of suitable indices.

ANNEX IV – Information categories selected and counted by preferred language/geographic context

Table AIV 1 Number of time information categories have been selected, counted by preferred language/geographic context.

		PREFERRED LANGUAGE/GEOGRAPHIC CONTEXT									Total
		Bulgarian	Czech	English	French	German	Italian	Polish	Romanian	Spanish	
INFORMATION CATEGORIES	Building and infrastructure documents	2	43	48	6	11		4	17	1	132
	Decision-making and communication		40	50	5	11		3	16	1	126
	Deconstruction/re-use of structures materials		26	38	3	7		7	21	1	103
	Funding and financing		43	36	5	3		1	23		111
	Implementation, control, monitoring (land back to market)		22	51	2	10		3	20	1	109
	Investigation (preliminary/detailed)		47	**81**	2	12		7	21	2	172
	Remediation strategies and options		42	73	7	25		10	24	3	184
	Remediation technologies evaluation and selection		30	**76**	11	22		10	22	3	174
	Requalification plan development		34	52	4	10		5	19	1	125
	Risk assessment (qualitative/quantitative)		37	72	10	19		7	22	1	168
	Socio-economic assessment		41	40	5				21		107
	Strategic planning		69	**77**	4	26	5	7	22	1	211
	Waste management		15	53	5	17		7	21	3	121
Total		**2**	**489**	**747**	**69**	**173**	**5**	**71**	**269**	**18**	**1843**

Table AIV 1 provides a general overview of information categories sorted by the different languages/geographic context. It shows that most of stakeholders search for information categories in English, Czech, Romanian and German. This may reflect the influence of the workshops organised during the TIMBRE project where stakeholders were invited to follow all the procedure steps instead of skipping the information category step, as probably happed for users who were not involved in the workshops. In general, users interested in information in English mostly selected information categories related to remediation aspects. Romanian stakeholders showed interest for remediation aspects too, which are immediately followed by "Funding and financing". Czech stakeholders mostly selected "Strategic planning".

ANNEX V - Relationships between search aims and information categories

The ISBR, as anticipated in paragraph 6.1, allows a deeper analysis of information needs. Indeed, it supports the identification of stakeholders' information needs also in terms of relationships between search aims and information categories. In the following (Table AV 1), three examples are reported, considering the three most clicked search aims sorted by language/geographic context, as reported in Table 11, and the related information categories.

Table AV 1 Number of selected information categories for the three search aims "Land regeneration / Sustainable BF regeneration" in English, "Best practices and successful case studies of BF regeneration" in English, and "BF database (lists of BFs with related data, e.g. localization, area, typology, former/historical utilization, contamination, etc.)" in Czech (see Table 3).

		INFORMATION CATEGORIES												
		Building and infrastructure documents	**Decision-making and communication**	**Deconstruction/re-use of structures materials**	**Funding and financing**	**Implementation, control, monitoring (land back to market)**	**Investigation (preliminary/detailed)**	**Remediation strategies and options**	**Remediation technologies evaluation and selection**	**Requalification plan development**	**Risk assessment (qualitative/quantitative)**	**Socio-economic assessment**	**Strategic planning**	**Waste management**
SEAECH AIMS	**(Land regeneration) Sustainable BF regeneration**	21	22	12	15	17	12	19	22	23	24	14	25	15
	Best practices and successful case studies of BF regeneration	12	15	8	12	14	18	14	18	12	16	12	17	10
	BF database (lists of BFs with related data, e.g. localization, area, typology, former/historical utilization, contamination, li	8	8	4	6	4	9	6	5	7	4	6	14	4