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EDITORIAL

Improving brownfield regeneration – a sustainable land take solution

Land is a finite resource. To protect unspoiled habitats and ensure sustainability we need to make sure it is used in the most efficient way possible. However, every year in the EU more than 1000 km² of undeveloped land is appropriated for housing, roads, industry, and recreation, without full consideration of diverse tangible and intangible services and values those soils provide. Brownfield remediation and regeneration represents a valuable opportunity, not only to prevent the loss of pristine countryside, but also to enhance urban spaces and remediate the sometimes contaminated soils. The European Environment Agency (EEA) has estimated that there are as many as three million brownfield sites across Europe, often located and well connected within urban boundaries and as such offering a competitive alternative to greenfield investments. However, their effective and sustainable regeneration will require the full support of planners as well as innovative and integrated approaches.

Unfortunately, no common legislation at European level for the sustainable use of soil resources has been adopted. Thus, there is a lack of impetus for a coherent approach for remedial soil protection, for a harmonised inventory of potentially contaminated sites and how to regenerate them efficiently. Another distinct consequence is the ongoing, unrestrained land take and continued soil sealing all over Europe, often even in regions with shrinking populations.

With uncertain levels of contamination, as a result of former industrial, commercial or military use, brownfield sites consume scarce soil resources and may cause environmental and health risks, as well as economic and social costs. Thus, the need to considerably reduce land consumption is increasingly recognised at both Member State and Europe-wide levels - the Roadmap to a Resource Efficient Europe[1] has set a target of no '*net* land take' by 2050. The re-use and development of brownfields is a major building block in strategies to achieve such political objectives. This is reflected by EU investment under the Seventh Framework Programme[2] in two key projects: Tailored Improvement of Brownfield Regeneration in Europe[3] (TIMBRE), and Holistic Management of Brownfield Regeneration[4] (HOMBRE), both focusing on enhanced uptake of innovative and existing methods, technologies and decision-support instruments.

This Thematic Issue from Science for Environment Policy brings together the latest research on brownfield remediation and redevelopment, exploring new tools and approaches and highlighting successful strategies from across Europe.

Decisions on brownfield remediation projects are long-term commitments and careful *ex ante* planning is required to ensure they are economic and effective. Decision Support Systems (DSSs) are designed to aid this process; however, there is a scarcity of tools which can manage complex spatial information and provide planners with clear results. The articles **'New tool to compare and prioritise brownfield sites for redevelopment'** and **'New framework to assess brownfield development potential'** both propose new DSS tools which combine environmental, economic and social concerns, allowing comparison of different brownfield sites over large areas and making planning options clear for a range of stakeholders to be involved in a sustainable revitalisation procedure.

Once such decisions are made, their impact and success must be evaluated. Successful planning policies used in different countries can help identify best practice and, provided local context is taken into account, can be of value to other nations. The article **'Policies to limit urban sprawl compared'** identifies the 'green belt'

planning approach taken in England, which protects a ring of undeveloped land around cities, as particularly successful in containing urban sprawl. Similarly, **'Brownfield best practices drawn from German and UK projects'** showcases Liverpool's and Cologne's two flagship waterfront developments and demonstrates the potential of brownfield regeneration to boost economies in poor areas.

There are many benefits of brownfield restoration and re-use; however, decontamination can be complex and costly, requiring soil, surface and ground-water remediation. This demonstrates that authorities (land users) need to take precautionary measures when developing land. Fiscal instruments to stimulate investment and guide land use to a more sustainable path can therefore be important policy tools to enable brownfield regeneration and reduce urban sprawl.

'Innovative funding mechanisms for urban brownfield regeneration analysed' demonstrates the key role of the public sector in encouraging private investment. Local governments in particular are well placed to reduce risks for private investors by providing locally relevant incentives, such as subsidised insurance, development fees waivers or property tax abatements. **'Portuguese tax to focus urban regeneration and increase transparency of development costs'** evaluates a new policy which discourages building outside urban areas by imposing heavier tax burdens. Tax relief incentives, on the other hand, are provided to encourage redevelopment of the city centre. Such approaches could be an option for other European cities aiming to stimulate brownfield regeneration.

Returns on financial investment are also clearly a driving factor in encouraging private developers. The article **'Model offers insight into long-term costs and payoff of brownfield redevelopment'** uses a case study in North America to explore how initial financial investment is balanced by economic gains as a result of redevelopment. It concludes that although governments and investors should be aware that the benefits of brownfield redevelopment can take several years to accrue, the longer term gains should not be underestimated.

Aside from financial concerns, the success of brownfield redevelopment relies heavily on the culturally rooted practices of local stakeholders and, as a result, the most effective strategies for brownfield regeneration may differ between regions. This is highlighted in **'Landscape quality plays important role in brownfield regeneration'** which demonstrates that, in Belgium, qualities that are often overlooked, such as cultural heritage and green spaces, are important to foster public support of brownfield regeneration schemes. While such local differences must be taken into account, the article **'Benefits to sharing experiences of soil remediation using 'Monitored Natural Attenuation'** demonstrates that there is also a need to foster communication between countries regarding common problems and solutions, so that best practices can be identified.

Finally, there is a need to look to the future of brownfield remediation, to ensure that every aspect of the process is sustainable and to identify innovative new methods. The article **'Good potential for sustainable re-use of demolition waste'** demonstrates that the challenge of disposing of old infrastructure from brownfields can create an opportunity to increase sustainability, by re-using such waste in the construction industry. **'Brownfield remediation combined with sustainable heating and cooling of buildings'** explores a pioneering approach to sustainable remediation taken in the Netherlands by decontaminating groundwater while also using it to regulate temperatures in offices. **'Phytoremediation's potential for decontaminating brownfields assessed'** explores how plants can be used to absorb and degrade pollutants. This 'green' approach was found to be effective for sites with medium or low contamination and was cheaper and more environmentally-friendly than traditional chemical techniques.

Brownfield regeneration and land use planning is complex and encompasses many different environmental, economic and social dimensions, often with consequences reaching far in to the future. Only a combination of methods, valuation or set of indicators will be able to cover this complexity, especially given the need to adjust to local context. The exemplary research presented in this issue shows that by using sustainability as the guiding concept, brownfield regeneration will be a stepping stone towards efficient use of land resources such as soil, water and nature. Thus, brownfield sites should be regarded as a valuable opportunity, not a costly problem.

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1 *http://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm*
2. *http://europa.eu/legislation_summaries/energy/european_energy_policy/i23022_en.htm*
3. *www.timbre-project.eu*
4. *www.zerobrownfields.eu*

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New tool to compare and prioritise brownfield sites for redevelopment

Researchers have proposed a new indexing scheme to help decision-makers prioritise brownfield sites for redevelopment. The scheme scores potential sites according to socio-economic, smart growth and environmental dimensions. By giving users the flexibility to emphasise some aspects of development as more important than others, it can be adapted for use in different contexts.

"The study proposes an indexing method that screens large areas and identifies sites to be considered for further assessment with the ultimate aim of redevelopment."

The majority of decision support tools (DSSs) for brownfield redevelopment are designed for specific projects and there are few tools to help compare different brownfield sites over a large area with the aim of prioritising sites for redevelopment.

The study proposes an indexing method that screens large areas and identifies sites to be considered for further assessment with the ultimate aim of redevelopment. The tool scores sites with three indices, which each incorporate appropriate indicators:

Socio-economic index: indicators for population density, property values and unemployment are combined in this index to indicate brownfield redevelopment's potential to contribute to economic growth.

Smart growth index: this indicates the 'liveability' of an area, and includes indicators which account for accessibility to utilities and transport, provision of employment opportunities and housing.

Environmental index: indicators including source of potential contamination, soil permeability, proximity to water bodies and parks and presence of wetland and floodplains, are combined in this index.

All indicators rely on publicly available data and information that can be collected in most industrialised countries, such as those in the EU. In the process of combining the indicators into the three indices, there is the option to weight the indicators according to their importance in a specific context. For example, if provision of employment was deemed most important for a particular area, this could be given greater weighting in the social growth index, or if the source of contamination was considered important, then the environmental index would give it greater weighting.

The researchers decided not to combine the three indices into one single index as their nature and spatial scale were incompatible. For example, socio-economic and smart growth indices can be applied on a regional or local level, whereas the environmental index is calculated for each brownfield site.

The framework was applied to the City of New Haven, USA, as a case study and provided three maps for each index. Using the environmental index, it assigned four sites out of 47 to the highest priority category for redevelopment. The case study demonstrated the sensitivity of three indices to the weighting schemes. As such, it is envisaged that participation of stakeholders would help to tailor the weighting according to local needs. Stakeholders would also have to consider other factors, such as availability and time-scale of funding, as well as public opinion.

The tool is not intended to replace evaluation of individual sites and redevelopment projects, but to serve as a preliminary screening tool for when there are a large number of potential sites or one large land area, in order to guide planning through initial choices.

Source: Chrysochoou, M., Brown, K., Dahal, G. *et al.* (2012). A GIS and indexing scheme to screen brownfields for area-wide redevelopment planning. *Landscape and Urban Planning* 105:187-198. Doi: 10.1016/j.landurbplan.2011.12.010.

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New framework to assess brownfield development potential

Researchers have proposed a new framework to assess the potential for redeveloping large contaminated brownfield sites. The framework applies a range of spatial assessment methods to analyse remediation costs, economic value and the sustainability of different land-use types, and to recommend suitably mixed land-use options for redevelopment.

"...the combined cost of restoring all large European brownfield sites likely exceeds €100 billion."

Redeveloping brownfields can address health, ecological and economic threats from contaminated land and leads to a more sustainable use of valuable land resources. However, remediating the complex below-surface contamination often present at brownfields is expensive: the combined cost of restoring all large European brownfield sites likely exceeds €100 billion. At large and complex brownfields, so-called 'megasites', the involvement of a large number of stakeholders adds further complexity to the process. Effective Decision Support Systems (DSSs) are therefore needed that can manage complex spatial information of such projects, provide transparent results for a range of stakeholders, and conveniently integrate an assessment of sustainability for different planning options.

The study proposes a DSS framework that fulfils these requirements. It allows the deterministic creation of land-use options for specific brownfield sites by integrating different models that consider ecological, social and economic aspects of redevelopment in order to provide a full 'sustainability' assessment[1]. These included:

An identification of **clean-up requirements** using spatial data on contamination and planned future land use, as well as data on concentration thresholds above which contaminants must be remediated:

- An estimate of **costs for the remediation** of soil and groundwater and deconstruction of derelict buildings
- An **assessment of the market value** of the site based on the quality of location (e.g., proximity to public transport, schools and amenities) and financial risks associated with the investment
- A summary **monetary assessment** based on the remediation costs and market value (see above)
- A **sustainability evaluation** based on the sustainability goals of local government planning policies

Within the framework, these models are applied to an integrated spatial assessment[2] of different uniform uses of the site. Thereby, those locations at the site are identified where different land-use types can most conveniently be allocated. The results are visualised in terms of maps that show economically optimal land-use allocations and guide further planning iterations. The research applied this framework to a case study site on the outskirts of Potsdam, Germany, where previous military use (petrol stations and dry cleaning facilities, among others) had led to severe subsurface contamination. Three land-use types were considered for the planning of redevelopment options at the site: residential, recreational and commercial. The study first mapped out an optimised layout of land-use types by trading-off high land values and low remediation costs. At the study site, this resulted in a rather patchy land-use layout with no recreational areas, which was unlikely to be a realistic option for planners. On this basis, two guided iteration steps led to improved land use alternatives which—although more expensive—were significantly more sustainable.

The proposed framework provides a deterministic derivation of suitable brownfield development options, and enables a transparent communication of results in terms of comprehensive maps. Thereby it facilitates the initiation of constructive discussions amongst stakeholders and provides preliminary planning steps that can be fine-tuned to the priorities of the area.

Source: Schädler, S., Morio, M., Bartke, S. & Finkel, M. (2012) Integrated planning and spatial evaluation of megasite remediation and reuse options. *Journal of Contaminant Hydrology.* 127:88-100. Doi: 10.1016/j.jconhyd.2011.03.003.

1 *See: Schädler, S., Morio, M., Bartke, S. et al. (2011) Designing sustainable and economically attractive brownfield revitalization options using an integrated assessment model. Journal of Environmental Management 92: 827-837. Doi:10.1016/j.jenvman.2010.10.026*

2. *See: Schädler,S., Finkel, M., Bleicher, A. et al. (2013) Spatially explicit computation of sustainability indicator values for the automated assessment of land-use options. Landscape and Urban Planning 111: 34– 45. Doi 10.1016/j.landurbplan.2012.12.002*

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Policies to limit urban sprawl compared

There is a growing demand for new settlements in and around urban areas due to social, economic and population factors. However, this can lead to the loss of agricultural land and green spaces that provide essential ecosystem services and contribute to the wellbeing of local people. Several countries, such as the UK and Germany, have attempted to limit the growth of urban areas by encouraging the redevelopment of brownfield sites.

"The English planning system could learn from the more detailed environmental targets and greater differentiation between different types of urban sprawl, as used in the German system."

Centralised planning systems and the use of 'green belts' have helped to contain urban expansion in England and encouraged building on brownfield sites, according to a study which compared England and Germany's planning policies. The German planning system, in contrast, was not considered to be as effective in containing urban sprawl, although it was better at identifying different types of sprawl.

The policies and planning systems used to limit urban sprawl and support the redevelopment of brownfield sites have had mixed success. To understand the factors that could explain these differences, the study analysed the rate of urban sprawl and relevant planning documents in England, UK, and Germany.

In England, national data show that 77% of new homes built in 2008 were constructed on brownfield land, up from 57% in 1996. The UK also uses the National Land Use Database of Previously-Developed Land to monitor reuse of brownfield sites. The data suggest policies to limit urban expansion are succeeding.

The main land use statistics used in Germany focus on the absolute growth of settlement and transport areas. This fell from 120 hectares per day between 1993 and 1996 to 113 hectares per day between 2003 and 2006. To compare land use in the two countries directly, the study used CORINE[1] satellite data. This revealed that the settled area in Germany grew four times faster than the UK (6.7% compared to 1.8%) between 1990 and 2000. The corresponding land take in Germany (174,393 hectares) was almost six times higher than in the UK (30,397 hectares)

The study also found significant differences in planning policies and attitudes to urban expansion. For instance, planning policies in England stem from the 1940s' urban containment policy and the use of green belts (which have significant public support). Green belts restrict development on a band of countryside surrounding a town or city. Planning policy statements have also prioritised the redevelopment of brownfield sites. The result is strict top-down controls over urban expansion.

In contrast, the German approach to planning policy includes a strategic 'spreading' into rural areas while balancing competing land use interests. There is no direct equivalent to green belts and planners are engaged in a national discussion about whether to accept and plan for low-density, car-dependent urban expansion. However, a policy aim to reduce urban sprawl was introduced in 2002, and a planning premise of internal before external development, driven in part by environmental concerns. Local authorities are responsible for the majority of planning decisions in Germany. This explains Germany's poorer results in containing urban sprawl compared to England.

The key role of central government, together with more comprehensive planning policies, mean that English planners could implement a target of 60% for building new homes on brownfield sites and have limited urban expansion more successfully. The English system could, however, learn from the more detailed environmental targets and greater differentiation between different types of urban sprawl, as used in the German planning system.

Source: Schulze Baing, A. (2010) Containing Urban Sprawl? Comparing brownfield reuse policies in England and Germany. *International Planning Studies.* 15(1):25-35. DOI: 10.1080/13563471003736910.

1 *http://www.eea.europa.eu/publications/COR0-landcover/page001.html*

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Brownfield best practices drawn from German and UK projects

Two 'best practice' case studies of brownfield regeneration in Germany and the UK have been analysed by researchers. Liverpool's and Cologne's two flagship waterfront developments were chosen in order to provide insights for other redevelopment projects. The assessment demonstrates that, if correctly managed, brownfield sites can help stimulate economic development in poor areas

"...despite substantial investment in brownfield regeneration in Europe, more holistic approaches and best practice guidelines are still needed."

Brownfield regeneration is a key policy objective to help cope with rising populations in urban areas in some parts of the EU. In 2005, 500,000 hectares of brownfield land were estimated to be available for development in Europe.

The researchers say that, despite substantial investment in brownfield regeneration in Europe, more holistic approaches and best practice guidelines are still needed. Interested in how brownfield regeneration could lead to economic growth and the creation of sustainable communities, they compared brownfield regeneration policy and practices in the UK and Germany, focusing on two case study waterfront sites of similar size and type: King's Waterfront in Liverpool and Rheinauhafen in Cologne.

To assess the sites, they surveyed local residents, collected information from stakeholders including city councils and developers, and conducted a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis for each site.

King's Waterfront is situated in one of the UK's most deprived areas. Previously a deserted car park, £390 million (ca. €560 million in 2005) of investment from EU and UK-based public and private sector partners has enabled redevelopment of the site into an office, retail, leisure and community space. The redeveloped site is expected to create 2,200 new jobs and millions in visitor spending per year. The central area and conference centre has good green credentials, including low carbon emissions and rain water harvesting. However, transport options are considered to be limited.

The Rheinauhafen site incorporates housing, offices, museums, leisure and retail units and a car park and was redeveloped at an estimated cost of €650 million, with funding largely provided by the EU's NORISC[1] project and private investors. Regeneration of the site is expected to create 2,500 new jobs and greatly boost the image of the area, which was once considered an eyesore. Some old buildings have been restored rather than replaced, which has helped make the development more sustainable whilst retaining some of the site's heritage. The site also incorporates a flood protection system. However, houses are not considered affordable.

The researchers' comparison finds that both sites are mixed use, attractive, sustainable and respectful of their heritage. They serve as catalysts for economic growth, but have limited housing types. Renewable energies have not been well implemented in either development and benefits for local neighbourhoods are limited.

Key differences between the sites include types of funding and the more innovative, recycled architecture at the Rheinauhafen site. Based on their study, the researchers say that brownfield regeneration practice is advancing the objective of 'urban renaissance', and King's Waterfront and Rheinauhafen provide examples of best practice, but that the uniqueness of each site means there is no single recipe for success.

Source: Maliene, V., Wignall, L., & Malys, N. (2012). Brownfield Regeneration: Waterfront Site Developments in Liverpool and Cologne. *Journal of Environmental Engineering and Landscape Management.* 20(1): 5-16. DOI:10.3846/16486897.2012.659030.

1 *http://ec.europa.eu/research/environment/newsanddoc/article_1442_en.htm*

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Innovative funding mechanisms for urban brownfield regeneration analysed

A recent study highlights the role of the public sector in encouraging private investment in natural and cultural brownfield regeneration projects by analysing four models of financing: public-private partnerships, land value finance mechanisms, urban development funds and impact investment funds. Local governments, it is suggested, are well placed to identify and select the most suitable financing mechanisms for redevelopment projects.

"The development and implementation of effective financing mechanisms is an essential part of successful brownfield redevelopment, especially in the current economic climate where investors are cautious."

The development and implementation of effective financing mechanisms is an essential part of successful brownfield redevelopment, especially in the current economic climate where investors are cautious. The study examines how different funding mechanisms may attract private investment to the redevelopment of natural urban brownfields, which have been environmentally affected, and to cultural heritage urban brownfields, which are abandoned historic districts. Given the difficulties that investors encounter in estimating financial returns and costs of this type of project, to be effective the funding mechanisms often require continuous incentives and a balance of public and private intervention. Governments (local, regional and central), can instigate private investment by reducing risks and by leveraging a combination of available public resource funds and private money through incentives, such as regulatory relief, subsidised insurance, waivers of development fees, property tax abatements and public investments in infrastructure and amenities.

With this balance of public and private investment in mind, the study analysed four models of financing brownfield redevelopment:

Public-Private Partnerships (PPPs). These vary, depending on which operations are supported by the public and private partners. To be effective, they need formal arrangements between partners and a clear identification of roles and responsibilities. In particular, close co-operation among the different partners - authorities, private actors, local residents - plays a key role in the success of a project.

Land Value Finance (LVF). These tools are designed to recover the capital cost of the urban investment by capturing some or all of the increments in land value resulting from the investment. The tools are very flexible mechanisms that can be used to finance a broad range of urban development and regeneration projects. For example, tax increment financing can encourage urban investment through either fiscal incentives as tax relief or through property tax specifically earmarked for the development.

Urban Development Funds. These have a broader scope that can integrate brownfield redevelopment within the funds themselves. A common example is the revolving fund, where developers obtain low-interest funds and the interest they pay flows back into the fund pool. In European countries the establishment of urban development funds investing in sustainable urban transformation is supported by a EU-wide initiative, Joint European Support for Sustainable Investment in City Areas (JESSICA[1]), which assists authorities interested in setting up this type of financial instrument.

Impact Investment Funds. These are socially responsible investments that are not exclusively driven by profit, but also provide social and environmental benefits. They tend to take the form of a balanced investment portfolio over a range of projects.

There are several innovative financial paths to support brownfield redevelopment. In order to choose the most appropriate option, all stakeholders need to understand the relationship between investment and the real estate market and establish formal and transparent partnerships. But above all, it is important to explore the context of the redevelopment project and encourage decentralisation for financing brownfield redevelopment, thus allowing for a better response to urban needs.

1 *See: http://ec.europa.eu/regional_policy/thefunds/instruments/jessica_en.cfm*

Source: Medda, F.R., Caschili, S., Modelewska, M. (2012). Financial mechanisms for Historic City Core Regeneration and Brownfield Redevelopment in *The Economics of Uniqueness: Investing in Historic City Cores and Cultural Heritage Assets for Sustainable Development.* Eds. Licciardi, G. & Amirtahmasebi, R. Washington D.C: World Bank.

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Portuguese tax to focus regeneration and increase transparency of development costs

A study has evaluated the Municipal Urbanisation Tax (MUT) - a specific tax for the construction, maintenance, and reinforcement of urban infrastructure - in the city of Tomar, Portugal. This is a one-time charge applied to new development through land subdivision (Loteamento) or individual buildings, similar to an impact fee, and has a new, simplifed formula which reinforces efforts to contain urban sprawl. Other municipalities aiming to direct urban regeneration towards their brownfield sites, for example, could learn from this experience.

"The development and implementation of effective financing mechanisms is an essential part of successful brownfield redevelopment, especially in the current economic climate where investors are cautious."

Urban sprawl adds to commuter congestion and affects people's quality of life as we lose open spaces that offer recreation, biodiversity and food production. Urban sprawl also contributes to high, unsustainable energy consumption rates. The EU *Territorial Agenda 2020* highlights the challenge of preventing further 'loss of biodiversity, vulnerable natural, landscape and cultural heritage' associated with development[1].

Many European municipalities compete for new investment in development by keeping land use taxes artificially low. However, this policy has led to urban sprawl and created wider burdens on municipal budgets. All Portuguese municipalities are now updating their municipal land use regulations, including the MUT, following changes to the National Law.

By calculating a new tax structure for Tomar, the municipality aimed to:

- Restore balance between cost and benefit of infrastructure investments
- Reinforce a national effort to contain urban sprawl
- Simplify the tax formula
- Promote a simpler concept, making the calculation more accessible to the public
- Balance public and private interests, and support equity and social justice

They found that previous formulae for calculating the tax were too complex, and revenues were far lower than actual cost of cities' infrastructure investment. Previous MUTs usually allowed construction outside urban areas. However, current approaches, such as the new formula developed for Tomar, encourage compact development within city boundaries.

The municipality of Tomar has 43,000 inhabitants. The majority are scattered in smaller settlements, with just 16,000 living in the city itself. The researchers found that many outlying buildings are single-family homes, including weekend or summer houses. This type of development has risen due to permissive rural building regulations, even after 1994, when the first municipal planning instruments were enforced.

The new system discourages building outside urban areas, by imposing much heavier tax burdens, which correspond to a long term strategy to progressively forbid building outside urban areas. But planned industrial zones, along with smaller villages where infrastructure is already in place, will have reduced taxation to encourage young people to stay and to promote job creation. Equally, the regeneration of Tomar's historic urban centre is encouraged through tax incentives.

It is too early to measure the effects of the new MUT on urban development patterns. However, the process of analysing and improving the tax formula has provided insights into problems in Portuguese land use fiscal policy. One important element of the new tax system is a spreadsheet where users can see exactly how a change in location affects costs. Reducing fees to encourage investment is a political decision, but adds a significant burden to municipal budgets. Until now, stakeholders may not have been aware of this trade-off.

Source: Almeida, J., Condessa, B., Pinto, P., Antunes Ferreira, J. (2013). Municipal Urbanization Tax and land-use management—The case of Tomar, Portugal. *Land Use Policy.* 31(2013) 336-346. DOI 10.1016/j.landusepol.2012.07.017.

1 *Territorial Agenda of the Eruopean Union 2012: Towards an Inclusive, Smart and Sustainable Europe of Diverse Regions (2011).*

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Model offers insight into long-term costs and payoff of brownfield redevelopment

It can take six to seven years before the financial benefits of brownfield regeneration projects are realised, according to a new study which focused on redevelopment in Michigan, USA. The study examines liability issues, regulatory concerns, clean-up standards and funding mechanisms, and introduces a new model that informs debate on brownfield redevelopment policies and funding mechanisms.

"Brownfield redevelopment is a sustainable land use strategy that helps address urban sprawl and promotes economic development, bolstering the public tax base through new job creation.

Brownfield redevelopment is a sustainable land use strategy that helps address urban sprawl and promotes economic development, bolstering the public tax base through new job creation. Brownfield developers must negotiate site remediation, permits, liability, funding and economic viability. These issues are interlinked, which has led to experts requesting more dynamic brownfield redevelopment policy models to reflect their interrelatedness.

To help understand some of these dynamics, the study investigated brownfield redevelopment in Michigan, focusing on factors that affect how long it takes for a project's finances to eventually break even. The state of Michigan is considered a redevelopment leader thanks to its aggressive environmental clean-up efforts since the 1970s, spending more than $830 million (circa €630 million) to decontaminate brownfield sites.

To calculate the delay between when expenditures are incurred on brownfield projects in Michigan, and when tax benefits eventually accrue from redevelopment, the researchers developed a new model using 'system dynamics'. This computer-aided approach to policy analysis and design can help decision makers understand the behaviour of complex systems over time. The model used data from the Department of Environmental Quality (MDEQ) and US Conference of Mayors brownfield surveys.

Once stakeholders have committed to a redevelopment project, its budget will often run in deficit. The model incorporates this project deficit, reflecting the real situation that Michigan (and other US states) has faced since introducing brownfield legislation in the mid-1990s.

Taking cumulative expenditures and tax revenues into account, and modelling projects with a range of annual funding levels, the study finds that, in Michigan, projects take six to seven years to break even.

The new model also explains how the benefits of brownfield redevelopment take time to accrue, and that they are often discounted relative to immediate costs. Governments typically aim to revitalise brownfields to the economic benefit of the community, yet they must also promote public health by enacting strict environmental regulations that increase liability risks for stakeholders interested in redeveloping a contaminated area.

These sometimes contradictory goals can slow down revitalisation in areas with questionable – i.e. less tangible short term – economic benefits. Brownfield sites with even small amounts of contaminants may still be extremely challenging to remediate.

Source: BenDor, T.K., Metcalf, S.S., Paich, M. (2011). The Dynamics of Brownfield Redevelopment. *Sustainability* 3: 914-936. doi: 10.3390/su3060914. This study is free to view at: www.mdpi.com/2071-1050/3/6/914

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Landscape quality plays important role in brownfield regeneration

A new study from Belgium has gathered community views of brownfield regeneration. Results indicate that the often overlooked aspect of landscape quality, such as green spaces, visually-attractive areas and cultural heritage, is important in people's opinions of brownfield regeneration schemes.

"For brownfield regeneration projects to be effective, they should explore community views and consider all the functions that regenerated sites can perform, in addition to mere economical functions."

There is growing interest in brownfield regeneration across Europe, but it tends to focus on economic factors, such as job opportunities and commercial uses, and not the ecological, historical and visual properties of these sites. When regeneration programmes do not integrate local community views about perceived quality of the landscape, a lack of acceptance and thus negative public reactions are likely to result. For brownfield regeneration projects to be effective, they should explore community views and consider all the functions that regenerated sites can perform, in addition to mere economical functions.

The study adopted an approach from Landscape Preference Studies (LPS) to assess the public perception of landscape quality. This typically consists of surveys, questionnaires or interviews using photographs or computer visualisations to investigate public preferences.

Data on public perception of six regenerated sites in Belgium were collected from 460 respondents who lived locally to the sites. Three of the sites were economically-orientated, functioning as commercial projects and industrial parks, but remained underused. The other three sites were fully regenerated, but had a broad range of proposed land uses, including recreational, commercial and residential, as well as economical.

In part of the survey, respondents were asked to compare the three fully-regenerated sites with two German sites in the Ruhr area. One of these German sites (Duisburg) was 'conservationist', whereby development preserves old features of the site; in this case, disused blast furnaces were conserved and integrated into a large green space. The other German site was 'interventionist', with more focus on introducing modern features; on this site, modern buildings were mixed with some industrial remains.

Results indicate that community attitudes to brownfield regeneration projects are not automatically positive, especially for sites that have remained unused for a long period and are negatively perceived as 'empty' or 'inert', despite remediation.

Landscape quality, in terms of the site's attractiveness and presence of green space, was seen to play an active role in community appreciation of the sites, suggesting that these features deserve more attention when planning brownfield regeneration projects. In particular, introducing nature and vegetation is likely to lead to more positive views of regeneration.

There are interesting differences in views on conservationist and interventionist approaches to brownfield regeneration. It appears that industrial features have heritage value for some members of the population, such as young, skilled workers in the health/social or creative sector. However, retired residents reacted negatively to a post-industrial landscape. This indicates that the preferences of different populations need to be understood to help guide redevelopment. The researchers suggest that the LPS framework is helpful in understanding community expectations in order to inform brownfield regeneration projects that consider the many functions of sites.

Source: Ruelle, C., Halleux, J-M. & Teller, J. (2012). Landscape Quality and Brownfield Regeneration: A Community Investigation Approach Inspired by Landscape Preference Studies. *Landscape Research.* Doi: 10.1080/01426397.2011.647898

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Theme(s): Environmental technologies, Land use, Urban environment, Soil

Benefits to sharing soil remediation skills using 'Monitored Natural Attenuation'

Monitored natural attenuation (MNA) is a long-term, 'hands-off' approach to cleaning up contaminated land. New research has surveyed the current development of MNA in Europe and demonstrates a clear need for practitioners to systematically collect and learn from each other's experiences with this form of brownfield remediation.

"MNA's advantages include minimal waste production, lower cost and less labour than other techniques. There is also minimal disturbance to the environment onsite..."

The MNA approach uses a number of processes that reduce the amount, availability, mobility or toxicity of soil contamination to happen naturally - without human intervention. These processes include biodegradation, among other physical and chemical events that breakdown, transform or disperse harmful chemicals over time. Other processes used in MNA include dispersion, dilution and radioactive decay of contaminants. MNA's advantages include minimal waste production, lower cost and less labour than other techniques. There is also minimal disturbance to the environment onsite, and little or no contact between remediation operators and the contamination.

Progress must be closely monitored. MNA is a site remediation technique practitioners can use when they believe natural processes will meet site clean-up objectives in a reasonable time, with acceptable risk. MNA can be used alone, or in combination with other remediation techniques.

Researchers, supported by the EU's ERA-NET SNOWMAN project[1], investigated the use of MNA in Europe. They evaluated previous studies on the topic and questionnaires were completed by research and regulation experts in ten European countries. In addition, information regarding MNA was shared at a SNOWMAN workshop held in 2011 in France to gain further insights.

Their findings confirmed that Europeans have used MNA since the 1990s, and that its use is growing. Nonetheless, practitioners in Europe are short of shared information about its cost, effectiveness and timescales. There are still countries that do not apply MNA regularly (such as France), or that do not formally acknowledge MNA as a remediation technique (such as Finland). A possible reason for the latter could be the colder climate, which could affect the success of biodegradation processes. However, the study emphasises that more research is needed to truly understand the effects of temperature on natural attenuation.

Differences were revealed in how individual EU Member States or regions deal with MNA within the contaminated soil remediation legal frameworks, as well as varying protocols, and levels of acceptance and application, which makes for a complex picture. For example, there were key differences in the use of MNA for the protection of groundwater.

However, important similarities between countries were also identified, such as widespread acceptance of MNA and the importance of biodegradation as a natural attenuation process.

This study demonstrates that valuable information on MNA exists, but that it is not easily available. The study recommends create inventories and comparisons of European MNA information, not only to define best practice, but also to determine how effective this approach has been over the longer term. A similar statement (regarding an urgent need to collect and share information on soil remediation), was made in the Common Forum and NICOLE Common Position Paper on Innovative Technologies in 2009[2].

Source: I. Declercq, V. Cappuyns, Y. Duclos (2012). Monitored natural attenuation (MNA) of contaminated soils: State of the art in Europe - A critical evaluation. *Science of the Total Environment.* 426 (2012) 393–405. DOI 10.1016/j.scitotenv.2012.03.040.

1. ERA-NET SNOWMAN was supported by the European Commission under the Sixth Framework Programme. See: www.snowmannetwork.com
2. www.commonforum.eu/Documents/DOC/CommonForum_NICOLE_PositionPaper_Innovative%20Technologies.pdf

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Theme(s): Resource efficiency, Waste

Good potential for the sustainable re-use of demolition waste

Europe produces around 450 million tonnes of construction and demolition waste every year, representing a quarter of all waste materials. A recent study of construction and demolition waste suggests that, with the right policies in place, there are good opportunities to ensure sustainable practices through re-use and recycling.

"...construction and demolition waste has a high recycling potential and the best method of ensuring high recycling rates is to create a coherent waste management plan."

One challenge associated with sustainable brownfield redevelopment is how to deal with old buildings and infrastructure. Demolition of buildings and other manmade structures generates large volumes of waste and its environmentally-friendly disposal or re-use is vital. Concrete, brick and cement are the main constituents, along with smaller amounts of impurities, such as metals, glass and sulphates. Once the waste has been crushed to a suitable size and contaminants have been removed, it can be used as valuable aggregate, needed for the production of concrete.

In this study, researchers examined waste management practices across EU Member States and identified successful strategies developed by individual countries that could be adopted elsewhere. The Netherlands was highlighted as particularly successful in this area. A total of 90% of construction and demolition waste in the country is re-used or recycled. Such high rates can be attributed to targeted environmental policy which requires reduction in the production of waste, separation of waste to prevent contamination and provides incentives to the construction industry for use of materials reclaimed from waste.

This study suggests that such re-use can have multiple benefits. Firstly, the need for quarried stone is greatly reduced. For example, in Spain alone 7.7 million tonnes can be saved per year by substituting 20% of the natural aggregates used in concrete production with recycled waste. This conserves non-renewable resources and prevents environmental impacts, such as damage to natural habitats or groundwater pollution, caused by quarrying.

Secondly, if 20% of natural aggregates are replaced with aggregates recovered from concrete, the resulting concrete mix is of the same, or even higher, structural quality. Higher percentage substitutions do lead to a loss of quality, but the researchers highlight that there is great potential for use where structural strength is less important, such as paving or roof tiles. However, challenges to the sustainable re-use of such wastes remain. For example, to ensure waste is of a high enough quality to be used as aggregate, materials must be separated as much as possible during the demolition process to prevent contamination, a process which can increase costs.

The study concludes that construction and demolition waste has a high recycling potential and the best method of ensuring high recycling rates is to create a coherent waste management plan. They recommend that measures include legislation to ensure the correct treatment of waste, so that it can be effectively recycled, promotion of the use of recycled and re-used materials in the construction industry, and rigorously enforced waste disposal laws and clear identification of the responsibilities and obligations of each participant.

Source: Del Rio Merino, M., Gracia, P. I., Azevedo, I. S. W. (2010). Sustainable construction: construction and demolition waste reconsidered. *Waste Management and Research.* 28: 118-129. DOI: 10.1177/0734242 X09103841.

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Theme(s): Water, Environmental technologies, Urban environment

Brownfield remediation combined with sustainable heating and cooling of buildings

Pioneering methods used in the Netherlands combine remediation of brownfield sites with the use of groundwater for heat cold storage (HCS, or ATES: Aquifer Thermal Energy Storage) to achieve both low-cost remediation and sustainable use of energy. A new study demonstrates how HCS can be used to help decontaminate groundwater on brownfield sites.

"...Heat Cold Storage can be used to actually help decontaminate groundwater on brownfield sites, thanks to new techniques and technological developments."

In recent years, there has been a major increase in the use of HCS in groundwater in the Netherlands, with a view to use more sustainable sources of energy. Usually in HCS systems, with the help of a heat-pump and heat exchanger, the heating or cooling of buildings is used to cool or warm different zones in groundwater. Warmth that is stored in summertime in one groundwater zone is used for the heating of the buildings in winter. In summer, water that has reached low temperatures during winter can be used for cooling. But, difficulties arise if the water is contaminated, as is often the case on brownfield sites.

However, this study highlights how HCS can be used to actually help decontaminate groundwater on brownfield sites, thanks to new techniques and technological developments. The developers and researchers present two brownfield case studies from the Dutch cities of Eindhoven and Utrecht, which incorporated HCS systems, and highlight the benefits of combining technologies to achieve efficient and cost-effective outcomes.

Redevelopment of a brownfield site in Eindhoven created an opportunity to install heat-pumps to allow sustainable use of energy via HCS. However, groundwater at the site was polluted with contaminants from past industry, and the effective combination of remediation and HCS required special control of water flow to contain and eventually remediate the contaminants. To achieve this, rather than designating hot and cold storage zones, engineers developed a recirculation system with extractions that surround the contaminants. This meets energy demand and offers the opportunity to contain the contamination. This technique also provides the added benefit that natural degradation conditions can be optimised through the increased mixing of groundwater, and, when necessary, by adding substances to the water, such as nutrients.

Although exact figures were not available, initial calculations suggest that this innovative system resulted in approximately a 3,000 tonnes reduction in CO_2 emissions (30-50%) and a decreased consumption of natural gas from 2.8 to 0.6 million m^3. Although the use of electricity increased, from 2.4 to 4.7 million kilowatt hours as a result of heat-pump use, overall costs for heating and cooling were reduced by 30-40%, and there were no separate investments needed for remediation. After two years of operation of the system, the first monitoring results indicate that increased mixing has already led to a significant increase in natural degradation of the contaminants.[1]

The second case study was in the city centre of Utrecht. More than 20 new HCS systems were planned, but the proposed city centre suffers extensive groundwater contamination. Over the large areas considered, there were several different sources of contaminants mixed in the groundwater, making remediation targeted at any single source ineffective and would lead to extreme costs. A management zone was therefore designated, within which contaminants from several sources were allowed to mix. This enables sustainable use of city groundwater for HCS, so long as the surrounding groundwater was protected from any contamination. Results from a mathematical model demonstrated that, under this strategy, the risk of contamination of clean groundwater was low. Improvement of groundwater quality was predicted; increased mixing through the HCS leads to increased natural degradation, and over a 30 year period the total amount of chlorinated solvents was expected to decrease from 6,000 to 4,000kg.

Source: Slenders, H., Dols, P., Verburg, R. *et al.* (2010). Sustainable remediation panel: Sustainable synergies for the subsurface: Combining groundwater energy with remediation. *Remediation.* 143-153. DOI: 10.1002/rem.20246.

1. *Slenders H., Verburg, R. et al. (2012) Biowashing machines really can work, Experiences after two years with Sanergy, the sustainable combination of groundwater energy and remediation. Conference Sustainable Remediation, Vienna November 2012*

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Theme(s): Environmental technologies, Land use, Soil

Phytoremediation's potential for brownfield decontamination assessed

Compared with traditional remediation techniques used to remediate brownfield sites, supporters of phytoremediation argue that it is cheaper and more environmentally-friendly. A new analysis has reviewed its strengths, weaknesses, opportunities and threats, and suggests it is well suited to cleaning up sites with low to medium levels of contamination.

"For low to moderately contaminated sites, phytoremediation may provide an optimal and affordable solution."

There are a number of physical, chemical and biological processes for remediating soil, such as soil washing, chemical oxidation and incineration. More recently, researchers have proposed less invasive alternatives known as 'gentle' or 'green' techniques that conserve resources and minimise environmental impacts.

One of these approaches, widely viewed as the most ecologically responsible, is phytoremediation, which uses plants to extract, degrade, absorb or immobilise pollutants. Some plants considered for phytoremediation, such as short rotation coppice (SRC), have also been proposed as a source of bioenergy crops to help meet renewable energy targets.

It must be ensured that phytoremediation provides its promised benefits and that there are no large unconsidered negative impacts. Using past research and case studies, the study conducted a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of this remediation method to assess its general feasibility.

The **strengths** of phytoremediation are that it is likely to be publicly accepted and have minimal impact on the site itself. As well as remediating polluted land, the plants can provide other environmental benefits, such as soil erosion control and wildlife habitat.

Compared to more traditional techniques, it is cost-effective. For example, research has shown it is at least 50% less expensive than the process of excavation, which removes soil and treats it elsewhere. Heavy metal pollutants, such as copper and lead, could also be potentially recovered from the plants with the development of technologies, such as electrokinetics.

In terms of **opportunities**, phytoremediation could be combined with other traditional methods, such as soil washing, in so-called 'treatment trains', particularly when remediating mixtures of contaminants that require a range of treatments. Some studies have proposed using the remediation plants as a source of bioenergy, especially since the land is unsuitable for growing food crops. However, there is concern as to the content of heavy metals in the biofuels and by products that these crops would produce. As yet, little is known about this possibility.

The analysis also cites several **weaknesses** of phytoremediation, including the slowness of the remediation process and the limited applicability of phytoremediation to heavily contaminated land. **Threats** include the likelihood that water-soluble contaminants may leach out of the root zone of the plants and escape remediation. It is also possible that if the plants are eaten by wildlife, pollutants could enter the food chain.

Some brownfield sites are not remediated because of the expense or the decision that the level of contamination does not require remediation under current regulations. For these low to moderately contaminated sites, phytoremediation may provide an optimal and affordable solution.

Source: Gomes, H.I. (2012). Phytoremediation for bioenergy: challenges and opportunities. *Environmental Technology Reviews.* Doi: 10.1080/09593330 .2012.696715

A selection of articles on Brownfield Regeneration from Science for Environment Policy's News Alert.

Urban wasteland areas can be re-developed as rich ecological sites (7/3/13)

Researchers in Berlin have demonstrated that urban wasteland areas can be used as suitable habitats for a range of grassland species. Using simple and cost-effective measures to sow grassland seed mixtures, they found that such areas flourished despite poor soil conditions and high levels of impact from people.

A standard method to assess effective measures for contaminated site remediation (24/2/2013)

A standardised method to help choose the most cost-effective measures to remediate contaminated sites has been developed by Austrian researchers. The method takes into account a wide range of factors, including the principles of sustainability.

Potential new method to assess brownfield restoration (8/7/2010)

Researchers have developed a method to assess the sustainability of regeneration projects that could potentially be administered by a computer. The method tailors the universal goals of sustainability to specific local conditions.

Rhodococcus bacteria can help clean up fuel-contaminated sites (11/2/2010)

Fuel spillages and leaks from petroleum storage facilities can lead to serious pollution of soils and underground water. In a recent study, two strains of *Rhodococcus* bacteria were found to be effective at degrading a number of petroleum hydrocarbons and thus helping clean up contaminated sites.

To view any of these in full, please visit: *http://ec.europa/science-environment-policy*, and search according to publication date.

To receive articles like this in a free weekly News Alert, please e-mail your subscription request to *sfep@uwe.ac.uk*

Further reading

You may also be interested in reading the following reports and past Thematic Issues.

The Multifunctionality of Green Infrastructure (March 2012)
Green Infrastructure (GI) stands to improve quality of life in many ways, through its environmental, social and economic credentials, based on the multifunctional use of natural capital. This In-depth Report describes the different functions that GI seeks to execute and explores the scientific evidence behind its ability to perform these functions.
http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR3.pdf

Soil Sealing (March 2012)
Sealing soils with artificial, impenetrable surfaces interferes with the essential environmental, economic and social functions performed by soils. This In-depth Report explores the extent of Soil Sealing and its consequences for the water cycle and city temperatures.
http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR2.pdf

Urban Environments (February 2009)
Half the world's population live in cities. By 2050, the total number of urban dwellers is expected to nearly double, rising from 3.3 billion to 6.4 billion. How do we accommodate urbanisation while ensuring good quality of life and health? How do we minimise environmental damage but still develop our cities? This Thematic Issue provides a window into the research evidence that can help us create healthier urban environments and more sustainable urban policies.
http://ec.europa.eu/environment/integration/research/newsalert/pdf/11si.pdf

To view any of these publications in full, please visit: *http://ec.europa.eu/science-environment-policy*

Related Research Projects

A number of interesting and promising policy-relevant research projects related to Brownfield Regeneration are supported by the European Commission under the Seventh Framework Programme. Here is a selection:

ECOFINDERS
Ecological Function and Biodiversity Indicators in European Soils
http://cordis.europa.eu/projects/rcn/97538_en.html

HOMBRE
Holistic Management of Brownfield Regeneration
http://cordis.europa.eu/projects/rcn/97080_en.html

isoSOIL
Contaminant-specific isotope analyses as sharp environmental-forensics tools for site characterisation, monitoring and source apportionment of pollutants in soil
http://cordis.europa.eu/projects/rcn/89356_en.html

SOILCAM
Soil contamination: advanced integrated characterisation and time-lapse monitoring
http://cordis.europa.eu/projects/rcn/89336_en.html

TIMBRE
An Integrated Framework of Methods, Technologies, Tools and Policies for Improvements of Brownfield Regeneration in Europe
http://cordis.europa.eu/projects/rcn/97552_en.html

UMBRELLA
Using MicroBes for the Regulation of heavy metaL mobility and ecosystem and landscape scale: An integrative approach for soil remediation by geobiological processes
http://cordis.europa.eu/projects/rcn/97080_en.html

UPSOIL
Sustainable Soil Upgrading by Developing Cost-Effective, Biogeochemical Remediation Approaches
http://cordis.europa.eu/projects/rcn/92581_en.html

VOLANTE
Visions of LANd use Transitions in Europe
http://cordis.europa.eu/projects/rcn/96699_en.html

More information about EU-funded research projects under the Environment Theme of the Seventh Framework Programme for Research can be found here: http://*ec.europa.eu/research/environment/index_en.cfm?pg=environment*