The Interreg IVB North Sea Region Programme

Investing in the future by working together for a sustainable and competitive region

European Union — The European Regional Development Fund

# SKINT Water Series II

# Selling Sustainability in SKINT (SSIS)

*Richard Ashley, Ann Christensson, Johannes de Beer, Louise Walker, Sarah Moore & Adrian Saul*

# Contents

# PREFACE

Sustainability is a concept and an ideal that has been fashionable for some two decades. So to try to promote a scheme to improve services, human life, ecosystems or to provide supporting infrastructure it is obligatory to claim that it is sustainable or at least “as sustainable as possible”. Because of this, “sustainability” as a term has become so devalued in common usage as to no longer carry meaning. This document is Volume 2 to a companion document (Volume 1) that used selected transnational cases to illustrate how different aspects of integrating land and water management processes have been undertaken. Innovative solutions were presented, together with organisational structures, communication tools and difficulties, as well as key-success factors. In Volume 1, sustainability assessments were introduced at a high and subjective level.

Volume 1 did highlight, however, how one of the most controversial, but crucial aspects for integration of land and water management is how sustainability is considered and assessed. The term “sustainable”, embodied in the Lisbon and Gothenburg Agendas, has often been exploited and misused by decision-makers. This volume on sustainability presents past, current and upcoming approaches to sustainability and sustainability assessments based on a selection of transnational cases, and proposes an initial description and definition of a common strategy for sustainability and sustainability assessment in land and water management processes in future projects.

This second volume of the SKINT Water Series further elaborates on this theme, and presents and evaluates an operational tool that will allow teams of users to produce integrated sustainability assessments for flood risk and water management applications, based on the idea of sustainability framing within the context of multivalue benefits.

The overall aim of SKINT has been to provide professionals and decision makers with procedures and tools to demonstrate the need for, and benefits of, adopting more sustainable solutions to a wider public, which although it has heard of the need for sustainability is not quite sure what it is about.

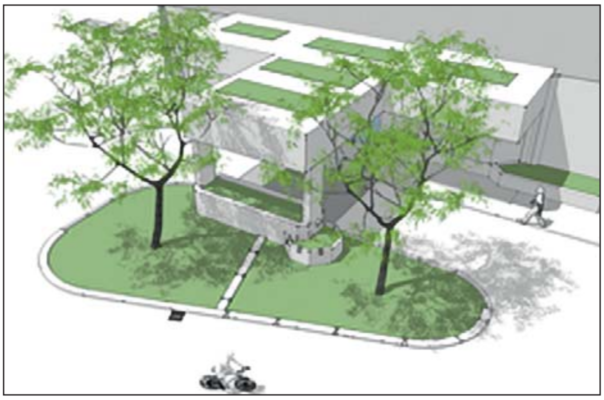
This volume of the SKINT Water Series concludes with a “lessons learned” section, based on a novel presented benefits matrix approach. This provides a transnational analysis about how to integrate water in urban land use projects from the start in order to improve the integration of the land and water management processes.

Summer 2012 The Editors

# 1. Introduction

SKINT WP4 is concerned with "selling sustainability in SKINT" (SSIS). There is a need for a "big message" to engage politicians and policy makers in the longer-term to think, plan and ensure sustainability in systems, services, the environment and above all human living. As SKINT considers the relationship between land use planning and the management of (surface and groundwater) water systems, there is a need to maximise the beneficial use of land in urban areas, manage water quantity and quality concurrently and seek ways of delivering multi-value from multi-used and multifunctional land and water systems and features (Digman et al. 2012, Figure 1)[1] .


A park-stormwater storage area in Seattle, USA that has been retrofitted into a residential neighbourhood to stop flooding by demolishing properties (photo: Chris Digman)



A retrofitted rain garden designed to add green infrastructure into the dense urban area of Victoria in London in a new Business Improvement District (image courtesy of: Scott Nixon)

**FIGURE 1(A) & (B). EXAMPLES OF MULTI-FUNCTIONAL USE OF STORMWATER SYSTEMS**

Much of the value and benefits accruing from land use are linked to the specific place in which the changes in systems, land use and functionality are to be delivered.[2] Holistic design that takes into account local social and economic geography can and should deliver several functions from the one project. For this to happen, the traditional narrow range of design inputs and boundaries needs to be broadened. This adds complexity, but brings multiple benefits.

Delivering multi-value and multi-functional land use and wide societal benefits requires cooperation between all parts of SKINT and integration of the various approaches and analyses. SKINT considers sustainability in two ways:

- At a strategic, conceptual, theoretical and scientific level
- Operationally – defining how best to apply the concept in the beneficiary case studies

---

[1] From : Digman, C J, Ashley, R M, Balmforth, D J, Balmforth, D W, Stovin, V R, Glerum, J W (2012). Retrofitting to manage surface water. C713 © CIRIA 2012 RP922 ISBN: 978-0-86017-915-9 CIRIA Classic House 174-180 Old Street, London.

[2] Owen A., Michell G., Clarke M (2011). Not just any old place: people, places and sustainability. Proc. Institution of civil engineers. Engineering Sustainability. 164 Issue ES1 Paper 1000016 5-11

In each of these aspects, the focus is on anthropocentric sustainability, i.e. it needs to be human-centred and is often expressed in terms of a human worldview or "human dignity" when punctuated by disruptive discontinuities or destabilisation.[3] Of course, in parts of the world where there has never been any sort of sustainability, security of life, welfare and hope for the future, sustainability has a different meaning which has to do with survival. On a large scale, the EU has a Blueprint to Safeguard Europe's Water,[4] which has established that most citizens understand issues around water; but the delivery of EU policies related to water is far from certain.[5] The inter-relationship between green urban areas and the water cycle in Europe is increasingly being recognised as important, not only for biodiversity, but also for quality of life and for the opportunity to use water and green infrastructure synergistically.[6] The Green City index has defined a number of criteria that seem to help contextualise how green a city will be.[7] These include: governance; the need to take a holistic approach; the importance of wealth; civic engagement; technology; having a green and brown agenda; and dealing with informal settlements. This interpretation of how cities may increase their "sustainability", becoming attractive and to some extent self-sustaining, shows how city planning and functioning have to be seen to operate hand in hand. Such visions are key elements in the task of selling sustainability.

This vision sets the scene for considering the two aspects of sustainability above, strategic and operational, in the SSIS methodology.

---

[3] van Egmond N D., de Vries H JM (2011) Sustainability: The search for the integral worldview. Futures 43 853-867

[4] *http://ec.europa.eu/environment/water/blueprint/index_en.htm* accessed 10-08-12

[5] van Leeuwen C J., Frijns J., van Wezel A., van de Ven F (2012). City blueprints: Indicators to assess the sustainability of the water cycle. Water Resources Management. ISSN 0920-4741. Vo. 26 No. 8. 2177-2197.

[6] EC (2011) Our life insurance, our natural capital: an EU biodiversity strategy to 2020. Communication From The Commission To The European Parliament, The Council, The Economic And Social Committee And The Committee Of The Regions {SEC(2011) 540 final} {SEC(2011) 541 final}

[7] *http://www.siemens.com/entry/cc/en/greencityindex.htm* accessed 10-08-12

# 2. Sustainability and SKINT

Globally we are no closer to a definition of what sustainability is or how it can be attained, despite some decades of research, development and attempts at delivery in practice. There is, however, agreement that "sustainability science" is about practice and is "use-inspired". [8] There has been a growing understanding that the future is much more uncertain than previously thought and that the ability to use probabilities to predict environmental and other phenomena based on quasi-stationarity is very limited.[9] There are nonetheless many definitions, principles, objectives, ideas and even policies that refer to sustainability. Because of this, sustainability is now a somewhat devalued term due to overuse, misuse and abuse by politicians and others – *everything* is now presented as being sustainable or as forming part of sustainable development.[10] This is very evident in the new planning policy for England, revised in 2012: "*so that it is clear that development which is sustainable can be approved without delay" (ibid)*. How it is possible to be *clear* about *development that is sustainable* is nothing short of miraculous, given that there is no consensus as to what the term means, nor how to achieve development that is sustainable. Thus it appears that locally defined versions of sustainable development are being used, particularly in urban planning processes, although private enterprise now also sees it as a selling point,[11] as illustrated in Figure 2.

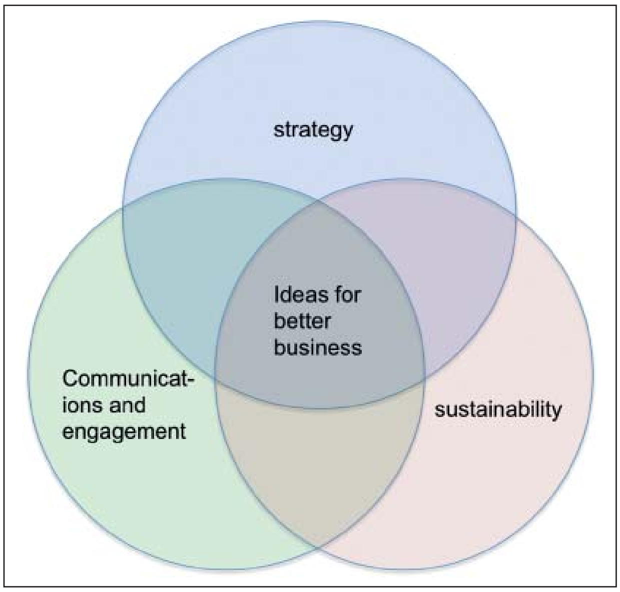



**FIGURE 2. THE BUSINESS IDEA OF SUSTAINABILITY**[5]

Such representations see sustainability simply as part of the pattern for business processes, rather than as required, which are business processes being part of sustainable living.

There is evidence from recent Swedish research and elsewhere that the professionals involved and other main actors may hold a "vision" of sustainability that is poorly defined [12] but broadly understood. This vision can assist professionals in their discourse with others in changing practice from being "less sustainable" to "more sustainable", despite there being no agreed framework for this, nor any definable or measurable parameters – e.g. changing from piped drainage to SuDS systems, presuming the latter are more sustainable than the former, despite evidence for this being sparse.[13,14]

---

[8] Kates R W (2011) What kind of science is sustainability science? PNAS December 6 Vol. 108, No. 49 19449-19450.

[9] Milly, P. C. D., et al (2008). Climate Change: Stationarity Is Dead: Whither Water Management? Science, 319, 573.

[10] "*So sustainable development is about positive growth – making economic, environmental and social progress for this and future generations…Pursuing sustainable development involves seeking positive improvements in the quality of the built, natural and historic environment, as well as in people's quality of life*" From: National Planning Policy Framework (2012) Department for Communities and Local Government, England. March. ISBN: 978-1-4098-3413-7 *www.communities.gov.uk*.

[11] E.g. Baxter S (2012) Sustainability forever? Embedding sustainability in your brand and culture. DIRECTIONS. Feb 2012. Ashridge. *www.salterbaxter.com*

[12] Cettner A. et al (2012). Sustainable Development And Urban Stormwater Practice. Subm. J. Env. Policy and Planning

[13] In the UK "SuDS" (sustainable drainage systems) are presumed to be those that deal with stormwater using systems other than buried underground pipes. In England and Wales the term SuDS has been enshrined in legislation since 2010. Nevertheless there is scant evidence that these systems are any more or less sustainable than alternatives such as piped drainage, as sustainability is dependent on context and therefore different for each application.

There are similarly a multitude of sustainability assessment tools, frameworks, criteria, indicators and categories, most of which are context-dependent and static (i.e. not allowed to evolve dynamically).

Because of the confusion around the meaning of sustainability, emerging ideas now relate to the process rather than the goal – there is consensus that sustainable development (or movement towards more sustainable systems) is an evolving process and that the "journey", of which we understand many of the characteristics, is more important than the unknown end point which is some sort of "sustainable" utopia. Recent initiatives linking water and city planning known as "City Blueprints" attempt to define criteria and indicators for moving towards integrated water management (within cities).[5] However, so far there have been no convincing applications of this approach. The leading thinking for sustainability has now passed to the sustainable transitions movement (moving from a less sustainable regime to one that is more sustainable), together with the promoters of resilience.[15,16] Resilience ensures that the functioning (goods and services provided) of existing systems is recoverable following an (external) disturbance.[17]

Sustainable transitions and resilience ideas fit well with the transnationally agreed-upon understanding and accounting processes developed for ecosystem services – these services provide support to humanity (help sustain) and in turn humanity needs to provide support to ensure that ecosystem services can themselves be sustained.[18] These approaches allow much more detailed assessments of ecosystem-related benefits derived by society from changing systems and services, such as water, to be made than has previously been possible, and also to consider how best to provide these benefits expressed in transnationally-agreed monetary terms.[19,20]

Initial attempts to produce a discussion template for use with stakeholders in deciding upon "sustainable" flood and water management options had a lukewarm reception within SKINT. This is not unusual. The difficulties in applying sustainability policy and ideals practically have been previously discussed[21] based on findings in the NORIS INTERREG IIIb project. Problems with operationalising sustainability into practice are well known[22], as most practitioners claim to adhere to some form of sustainability assessment whilst actually simply, at best, adopting a "tick-box" approach. It is recognised that whilst practitioners need to be able to substantiate claims of delivering projects and schemes that are moving towards greater sustainability for the options they choose, frameworks for assessment have not been agreed for widespread and uniform application (e.g. TISSUE[23]) and therefore have significant limitations, rendering them (or at least resulting in them being perceived as) too time-consuming and confusing in their use.[24]

---

14 Ashley R M., Blackwood D., Butler D., Jowitt P., Davies J., Smith H., Gilmour D., Oltean-Dumbrava C. (2008). Making Asset Investment Decisions For Wastewater Systems That Include Sustainability. ASCE J Env. Engineering. Vol. 161. No. 3, March 1. DOI: 10.1061/ ASCE 0733-9372 2008 134:3 200. Winner of the IWA Prize for Research Excellence in Support of Sustainable Urban Water Management (Sept 2008).
15 E.g. Frantzeskaki N. et al (2012). Concluding editorial: Sustainability Transitions and their governance: lessons and next step challenges. Int. J. Sustainable Development. Vol. 15 No. 1/2 173-186
16 E.g. Pittock J. (2011) National Climate Change Policies and sustainable water management: Conflicts and synergies. Ecology and Society 16(2): 25 pub. online
17 Gersonius B et al (2012). Developing the evidence base for mainstreaming adaptation of stormwater systems to climate change. Water Research. In press
18 E.g. Sukhdev, et al (2010). The economics of ecosystems and biodiversity: mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB. TEEB Team, United Nations Environment Programme for the European Commission. (ISBN: 978-3-98134-103-4). Go to: *http://tinyurl.com/3ac6kc6*
19 Everard M. (2011) Why does 'good ecological status matter'? Water and Environment journal. ISSN 1747-6585. p1-10.
20 Bateman I J., Mace G M., Fezzi C. et al (2010). Economic Analysis for Ecosystem Service Assessments. Environ Resource Econ. Springer. DOI 10.1007/s10640-010-9418-x pub. Online 13th October
21 Hurley, L., Ashley, R., Mounce, S. (2008) Addressing practical problems in sustainability assessment Frameworks. *Proceedings of the Institution of Civil Engineers, Engineering Sustainability*. Issue ES1 Pages 23–30 doi: 10.1680/ensu.2008.161.1.23
22 Palme, U., Tillman, A.,M., 2007. Sustainable development indicators: how are they used in Swedish water utilities? Journal of cleaner production 16 (13), 1346-1357.
23 TISSUE (2005). Trends and indicators for monitoring the EU thematic strategy on sustainable development of urban environment. Final Report. Summary and Recommendations. Contract SSP1-CT-2003-502427. April.

Nevertheless, practitioners in the water and other sectors usually have a vision of sustainability that is both personal and held within their institutional culture3 based on established principles, such as:[25]

(1) Substances from the lithosphere must not systematically increase in the ecosphere;
(2) Substances produced by society must not systematically increase in the ecosphere;
(3) The physical basis for the productivity and diversity of Nature must not be systematically deteriorated;
(4) Fair and efficient use of resources with respect to meeting human needs.

There is also an acceptance that the "sustainable city" is in fact not an entity that can be defined once and for all, but is considered as "*an issue in continuous transformation and evolution*"[26,27]; hence sustainable development is a process or a journey rather than a destination or a defined goal.

Despite the above, it is still common to utilise "indicators", "criteria" and/or "attributes" to determine whether or not an intervention, option or response that changes infrastructure systems is likely to create "more or less" sustainability.[28] This is because no better alternative has yet emerged. This approach can be defined as the POCIA method: Principles-Objectives-Criteria-Indicators-Attributes.[29]

Stormwater management in the USA has been successfully transformed in some areas in part by the ability to "sell" the benefits of innovation to practitioners. The "triple bottom line" of economy, environment and society is acknowledged but is defined in monetary terms for the value of "green infrastructure"[30] and is becoming *the norm*[31,32]. For example the City of Cuyoga Falls, Ohio USA where 4 flood-damaged properties have been demolished and a GI flood storage area created in their place that has multi-functional value as a park[33], similarly to the illustration in Figure 1a. Figure 3 shows examples from the 'Emerald City' initiative in Philadelphia USA where the multivalue benefits of doing this have been calculated.

---

[24] Palme U.,Tillman A-M (2009). Sustainable urban water systems in indicators : researchers' recommendations vs practice in Swedish utilities. Water Policy 11 p250-268
[25] Holmberg, J., 1995. Socio-ecological principles and indicators for sustainability. PhD thesis. Göteborg: Institute of Physical Resource Theory, Chalmers University of Technology and Göteborg University.
[26] Maiello A., Battaglia M., Daddi T., Frey M. (2011). Urban sustainability and knowledge: Theoretical heterogeneity and the need of a transdisciplinary framework. A tale of four towns. Futures 43, 1164-1174
[27] Beck M B (2011) Cities as Forces for Good in the Environment – Sustainability in the Water Sector. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, Georgia. (ISBN: 978-1-61584-248-4).
[28] Ashley R M., et al (2008). Making Asset Investment Decisions For Wastewater Systems That Include Sustainability. ASCE J Env. Engineering. Vol. 161. No. 3, March 1. DOI: 10.1061/ ASCE 0733-9372 2008 134:3 200.
[29] Hurley L., Ashley R M., Molyneux-Hodgson S., Moug P., Schiessel N. (2010) "Measuring" sustainable living agendas. Management of Environmental Quality. 21. 45-57.
[30] CNT (2010) The Value of Green Infrastructure A Guide to Recognizing Its Economic, Environmental and Social Benefits. Available online : *http://www.cnt.org/repository/gi-values-guide.pdf*
[31] American Rivers et al (2012). Banking on Green.
*http://www.americanrivers.org/assets/pdfs/reports-and-publications/banking-on-green-report.pdf (accessed 24-04-12)*
[32] Thurston H W. Ed. (2012) Economic incentives for stormwater control. CRC Press. Taylor & Francis. ISBN 978-1-4398-4560-8
[33] The 24,000 ft² park drains 3.17 acres and is the lowest point in the block. It was developed with rain gardens, pervious concrete pavement, pervious recycled tire pavement, and solar powered lighting. Three rain gardens were installed on the site demonstrating a commercial size rain garden of 6,000 ft² and two residential size rain gardens of approximately 100 ft². Site conditions limited the ability of an underdrain system for the rain gardens. Instead, an overflow pipe was used for flow during peak rain events. *http://planning.co.cuyahoga.oh.us/infrastructure/pdf/raingarden.pdf*
[34] Everard M., Shuker L., Gurnell L. (2011) The Mayes Brook restoration in Mayesbrook Park, East London: an ecosystem services assessment. Environment Agency – April 2011. *www.environment-agency.gov.uk*
[35] Rouquette J., Kumar V., Hornby S., Lerner D N. (2011). Developing sustainable urban riversides: an approach and preliminary results. Cities of the Future Conference. Stockholm.

**FIGURE 3. PHILADELPHIA WHERE RETROFITTING GREEN INFRASTRUCTURE TO MANAGE STORMWATER IS DE RIGEUR (COURTESY M MAIMONE, CDM SMITH)**

This approach enables decision-makers to take a broader view of the benefits associated with more sustainable surface water management and green-blue infrastructure and to demonstrate the benefits to multiple stakeholders, including those supplying the funds or making the decisions, as has been done very successfully in the Mayes Brook Park in NE London.[34] It also allows direct comparison with more traditional grey infrastructure (piped) solutions. It even inspires private investors to contribute to what are civic benefits.[32]

This "reduction" of indicators of sustainability to monetary value has been criticised, particularly in relation to social and environmental factors, but many years of research in the area has not yet produced an acceptable system for the incorporation of all sustainability ideals that respect the point of view of the core disciplines involved.[22] Meanwhile, measures are being implemented which require careful consideration of their contribution to sustainability as part of a shared vision, frame or consensus locally, such as the 15 sustainability objectives given in Table 1.[35]

| |
|---|
| Supporting business, growth and investment |
| Uplifting property values |
| Achieving return on investment |
| Decent housing available to everyone |
| Conditions and services which engender good health and wellbeing and provide leisure and recreation opportunities for all |
| Safety and security for people and property |
| Land use patterns that minimise the need to travel or which promote the use of sustainable forms of transport |
| Efficient use of land which makes good use of previously developed sites and buildings |
| A quality built environment |
| Historic environment and cultural heritage protected and enhanced |
| Quality natural landscapes maintained and enhanced/created |
| Wildlife sites and biodiversity conserved and enhanced |
| Water resources protected and enhanced |
| Minimal risk to human life and property from flooding |
| Prudent and efficient use of energy and resilience to climate change |

**TABLE 1. SUSTAINABILITY OBJECTIVES ASSESSED BY EXPERTS IN SHEFFIELD CITY COUNCIL**

This report considers the approach within the context of selling sustainability in SKINT (SSIS) and proposes a method for this by facilitating the demonstration of the multi-value benefits of flood and water management techniques, coupled with urban land use planning and urban design, expressed in monetary terms.

# 3. SSIS METHODOLOGY

There has been much greater interest in surrogates of sustainability when the benefits of alternative means for managing water systems have been expressed in terms of monetised multi-values, for instance.[30] Emerging approaches are using the value of ecosystem services and assessing the multi-functionality from using green infrastructure in urban areas. Table 2 illustrates the potential contribution of GI to adaptation to climate change as an example.

| Water-related phenomena | Adaptation needs | How and why GI can help |
|---|---|---|
| Flooding | Managing surface water runoff | Urban development results in faster runoff of surface water, and higher rates and volumes of runoff, because the capacity for local retention/infiltration is diminished. An increase in green areas (GI) to reduce the rate at which rainwater runs off and increasing infiltration can help to better manage intra-urban flood risk. |
| | Managing overland pathways | An option to better manage intra-urban flood risk is to direct peak flood flows along green links where the risk to infrastructure, buildings and people is minimal. |
| | Managing fluvial pathways | GI can provide water storage and retention areas, reducing and slowing down peak flows, and thereby helping to alleviate flooding from rivers and urban watercourses. |
| Droughts | Maintaining water quantity | GI can provide a permeable surface which helps to sustain infiltration to aquifers, recharge groundwater and maintain base flow in rivers. |
| | Maintaining water quality | GI catches sediment and can remove other pollutants from the surface water, thereby ensuring that water quality is maintained; this is especially important in the UK where the quality of water sources from uplands is deteriorating ostensibly due to a changing climate. |
| | Maintaining the source | GI can assist with the provision and management of healthy and biodiverse catchments as a whole, reducing the stress on flora and fauna. |
| Heat | Managing high temperatures | Urban areas are at increased risk of heat waves due to the urban heat island (UHI) effect. UHI arises because materials used in cities (asphalt, concrete, bricks) store heat and release it slowly during the night, keeping urban temperatures higher than rural temperatures. GI can counteract the heat island effect of cities by providing shading and/or cooling through evapo-transpiration. |
| | Providing recreation | GI provides recreation services, so that people can enjoy positive consequences of climate change like warmer summers. |

**TABLE 2. THE POTENTIAL ROLE OF GI IN HELPING ADAPT URBAN AREAS TO CLIMATE CHANGE**[36]

Headline financial benefits of a proposed scheme that demonstrate considerable added-value appeal to decision makers; hence for SSIS a method has been developed whereby the multi-value benefits of proposed developments can be determined and expressed as far as practicable in monetary units. Recently in England, the Environment Agency showed that a flood alleviation scheme proposed at Mayes Brook Park in London had a benefit to cost ratio of 7, with the majority of financial benefits coming from cultural services[34] (Table 3). In Philadelphia, the added-value of using GI for stormwater management compared with piped storage systems was some $3bn;[37] a persuasive figure for the mayor to back the approach.

---

[36] Ashley, R M, et al (2011) Surface water management and urban green infrastructure – a review of potential benefits and UK and international practices. Foundation for Water Research, Bucks
[37] Valderrama A., Levine L. (2012) Financing Stormwater Retrofits in Philadelphia and Beyond. Natural Resources Defense Council. New York.

## 3.1 BACKGROUND

The criteria traditionally used for sustainability assessment in the POCIA approach are non-commensurate in that they have differing types of units (e.g. m³/s, species diversity, satisfaction of residents, €), some of which are quantifiable and others not. There are also complex interactions between the indicators, which are rarely independent. Therefore comparisons are not straightforward and multi-criteria and other analytical tools are often used to make sense of the many pieces of information to be considered.[28] Many decision-makers often view such tools with suspicion and more engaged processes are frequently required, such as elicitation of the preferences of stakeholders, either formally or informally.[38]

### 3.1.1 ECOSYSTEM SERVICES

The global Millennium Ecosystem Assessment[20,39] has provided the means to take an ecosystem services approach, whereby the natural environment is seen as of financial value to humanity and in turn can be affected by human behaviour, although the economic values themselves are understood to have no absolute meaning. They are most useful when considering marginal values of altered conditions (i.e. an improved condition compared with now) and whether these are likely to be significantly positive. This has provided for the first time a globally accepted approach to monetising many of the beneficial criteria and indicators relevant to sustainability assessment, especially those related to the natural environment. Table 3 provides the principal categories and specification for the ecosystem services criteria taken from the TEEB Manual for Cities: Ecosystem Services in Urban Management.[40]

| Ecosystem service | International icon | Service description |
|---|---|---|
| **Provisioning services: Ecosystem services that describe the material or energy outputs from ecosystems that can be used to support human needs** | | |
| **FOOD** |  | Ecosystems provide the conditions for growing food. Food comes principally from managed agro-ecosystems, but marine and freshwater systems, forests and urban horticulture also provide food for human consumption. |
| **RAW MATERIALS** |  | Ecosystems provide a great diversity of materials for construction and fuel including wood, biofuels and plant oils that are directly derived from wild and cultivated plant species. |
| **FRESH WATER** |  | Ecosystems play a vital role in providing cities with drinking water, as they ensure the flow, storage and purification of water. Vegetation and forests influence the quantity of water available locally. |
| **MEDICINAL RESOURCES** |  | Biodiverse ecosystems provide many plants used as traditional medicines as well as providing raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources. |

**TABLE 3. ECOSYSTEM CATEGORIES AND TYPES**

38 E.g. Kumar V., Rouqette J R., Lerner D N (2012). Integrated modelling for sustainability appraisal for urban river corridor (re-) development. Procedia Environmental Sciences. in press.
39 Watson, R & Albon, S (2011). UK National Ecosystem Assessment Understanding nature's value to society. Synthesis of the Key Findings. UK National Ecosystem Assessment, Cambridge
40 TEEB – The Economics of Ecosystems and Biodiversity (2011). TEEB Manual for Cities: Ecosystem Services in Urban Management. *www.teebweb.org*

| Ecosystem service | International icon | Service description |
|---|---|---|
| **Regulating services: The services that ecosystems provide by regulating the quality of air and soil or providing flood and disease control, etc.** | | |
| **LOCAL CLIMATE AND AIR QUALITY REGULATION** |  | Trees and green space lower the temperature in cities whilst forests influence rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere. |
| **CARBON SEQUESTRATION AND STORAGE** |  | Ecosystems regulate the global climate by storing greenhouse gases. As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues, thus acting as carbon stores. |
| **MODERATION OF EXTREME EVENTS** |  | Ecosystems and living organisms create buffers against natural disasters, thereby preventing or reducing damage from extreme weather events or natural hazards including floods, storms, tsunamis, avalanches and landslides. For example, plants stabilise slopes, while coral reefs and mangroves help protect coastlines from storm damage. |
| **WASTEWATER TREATMENT** |  | Ecosystems such as wetlands filter effluents. Through the biological activity of micro-organisms in the soil, most waste is broken down. Thereby pathogens (disease-causing microbes) are eliminated, and the level of nutrients and pollution is reduced. |
| **EROSION PREVENTION AND MAINTENANCE OF SOIL FERTILITY** |  | Soil erosion is a key factor in the process of land degradation, desertification and hydro-electric capacity. Vegetation cover provides a vital regulating service by preventing soil erosion. Soil fertility is essential for plant growth and agriculture and well-functioning ecosystems supply soil with nutrients required to support plant growth. |
| **POLLINATION** |  | Insects and wind pollinate plants, which is essential for the development of fruits, vegetables and seeds. Animal pollination is an ecosystem service mainly provided by insects but also by some birds and bats. |
| **BIOLOGICAL CONTROL** |  | Ecosystems are important for regulating pests and vector-borne diseases that attack plants, animals and people. Ecosystems regulate pests and diseases through the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural controls. |
| **Habitat or Supporting services: These services underpin almost all other services but do not necessarily have direct economic worth. Ecosystems provide living spaces for plants or animals; they also maintain a diversity of plants and animals and support the other ecosystem services.** | | |
| **HABITATS FOR SPECIES** |  | Habitats provide everything that an individual plant or animal needs to survive: food, water, and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movements. |
| **MAINTENANCE OF GENETIC DIVERSITY** |  | Genetic diversity (the variety of genes between, and within, species populations) distinguishes different breeds or races from each other, providing the basis for locally well-adapted cultivars and a gene pool for developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known as "biodiversity hotspots". |
| **Cultural services: These are the non-material benefits people obtain from contact with ecosystems. They include aesthetic, spiritual and psychological benefits.** | | |
| **RECREATION AND MENTAL AND PHYSICAL HEALTH** |  | Walking and playing sports in green space is a good form of physical exercise and helps people to relax. The role that green space plays in maintaining mental and physical health is increasingly recognised, despite difficulties of measurement. |
| **TOURISM** |  | Ecosystems and biodiversity play an important role for many kinds of tourism, which in turn provides considerable economic benefits and is a vital source of income for many countries. In 2008 global earnings from tourism summed up to US$944 billion. Cultural and eco-tourism can also educate people about the importance of biological diversity. |
| **AESTHETIC APPRECIATION AND INSPIRATION FOR CULTURE, ART AND DESIGN** |  | Language, knowledge and the natural environment have been intimately related throughout human history. Biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art, culture and increasingly for science. |
| **SPIRITUAL EXPERIENCE AND SENSE OF PLACE** |  | In many parts of the world natural features such as specific forests, caves or mountains are considered sacred or have a religious meaning. Nature is a common element of all major religions and traditional knowledge, and associated customs are important for creating a sense of belonging. |

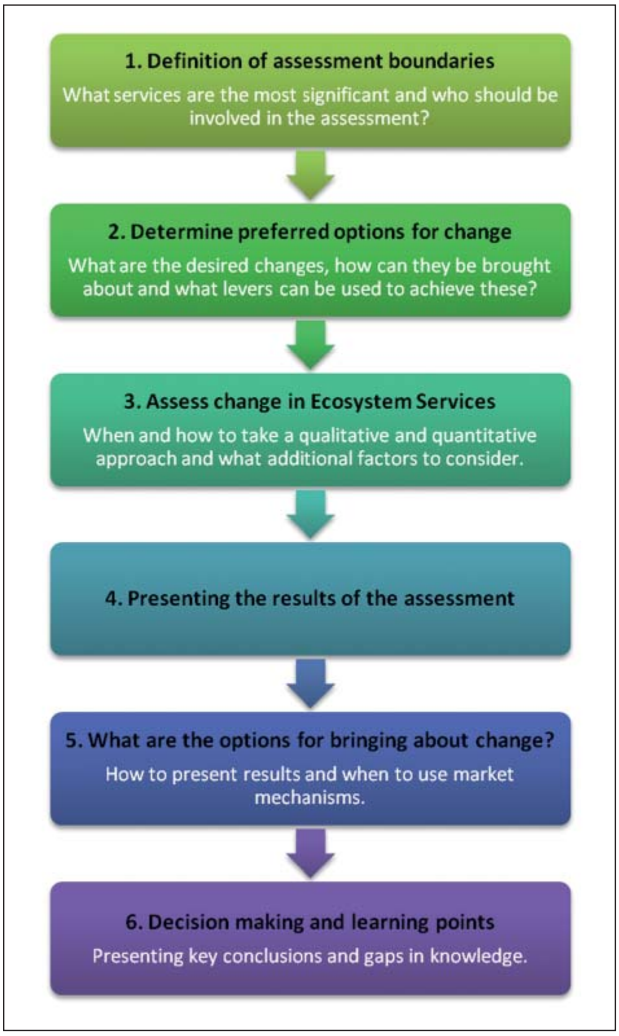



**FIGURE 4. USING ECOSYSTEM SERVICES IN ASSESSMENT PROCESS FOR VALUATION**

The monetary value of these services can be assessed using standardised national accounting estimates, agreed data bases,[41] local data or other methodologies (see section 4). This should be added to the traditional value of any infrastructure investments, normally expressed in terms of benefit-cost ratios. Figure 4 illustrates the components of the approach.[42]

Figure 5 shows the cost-benefit process, with only today's costs and benefits included for simplicity, although whole life performance needs to be considered. For a comprehensive assessment, discounted costs and benefits need to be included over a specified time horizon and account needs to be taken of future scenarios.[20] The estimation of this net present value (NPV) is not included in this report in detail, as guidance on this is given in many other documents[20,28,43,44] although it is further explained in the context of the matrix in Section 5.

---

41 E.g. EVRI The Environmental Valuation Reference InventoryTM. Provides an assessment of benefits transfer. *https://www.evri.ca/Global/Splash.aspx*

42 Everard M (2012) UK Environment Agency. Personal communication

43 Digman, C J, et al (2012). Retrofitting to manage surface water. C713 © CIRIA 2012 RP922 ISBN: 978-0-86017-915-9 CIRIA Classic House 174-180 Old Street, London

44 Commonwealth-Australia-6 2006. Handbook of Cost-Benefit Analysis. Financial Management Reference Material No.6

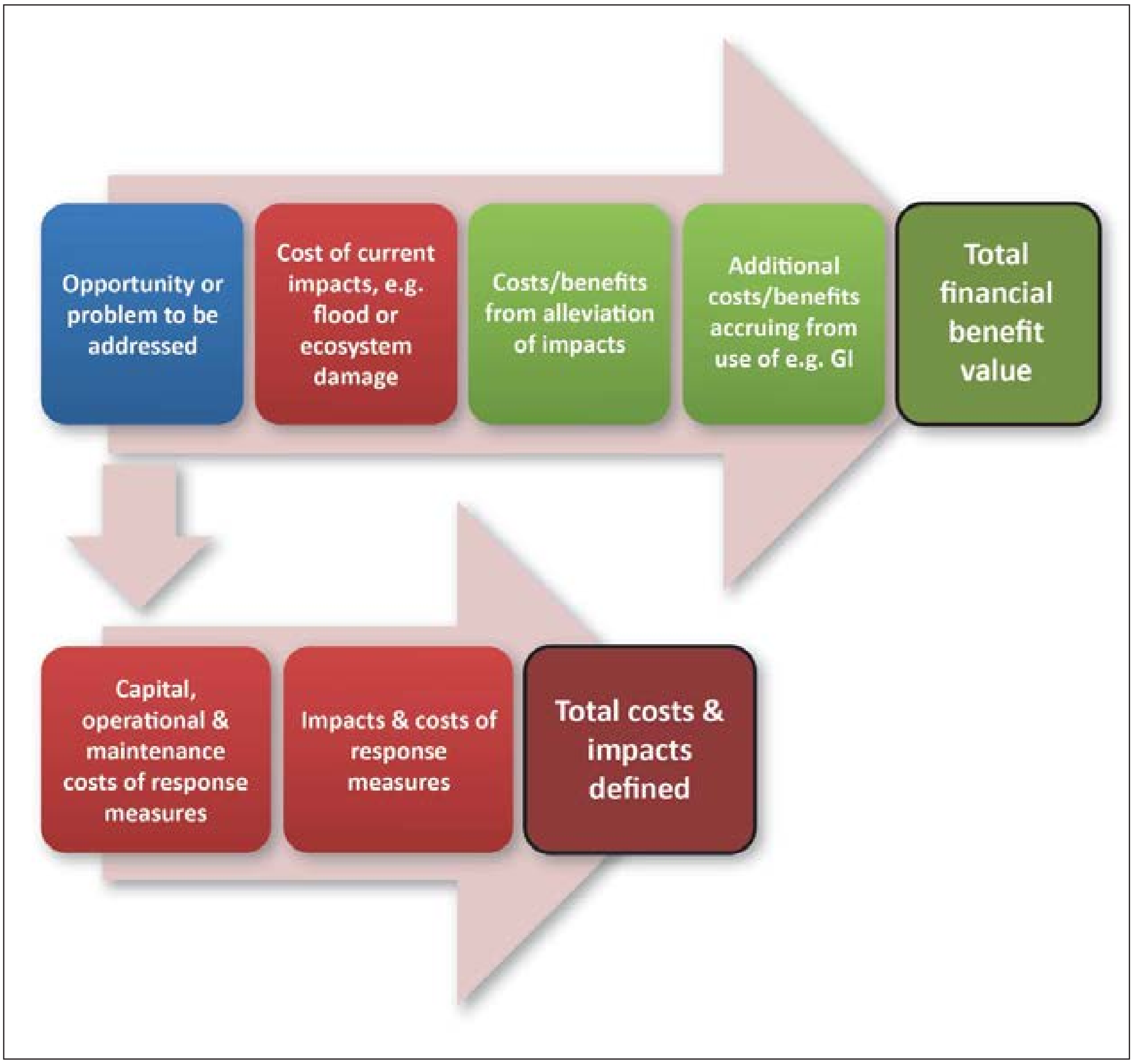



**FIGURE 5. COMPONENTS OF A BENEFIT-COST ASSESSMENT INCLUDING ECOSYSTEM SERVICES AND GI**

Where urban developments are planned, tools are available to assess their potential impacts, and standard impact assessments, such as EIA or SEA, are specified in EU and national standards and regulations, many of which differ in application and context.[45] The complementary Ecosystem Services Review for Impact Assessment (ESR for IA) provides practical instructions and spreadsheet tools for how to incorporate ecosystem services throughout environmental and social impact assessment.[46]

---

45 Glasson J., Bellanger C. (2003). Divergent practice in a converging system? The case of EIA in France and UK. Environmental Impact Assessment Review. 23, 605-624. Fischer T B. (2002) Strategic Environmental Assessment in post-modern times. Environmental Impact Assessment Review. 5284, 1-16. Therivel R. & Walsh F. (2006) The strategic environmental assessment Directive and beyond in the UK: 1 year onwards. Environmental Impact Assessment Review 26, 663-675.

46 Landsberg, F., et al (2011). Ecosystem Services Review for Impact Assessment: Introduction and Guide to Scoping. WRI Working Paper. World Resources Institute, Washington DC. Online at *http://www.wri.org/publication/ecosystemservices-review-for-impact-assessment*.

There are a number of methods available for the evaluation of the ecosystem services and other measures of multiple benefits in the water domain. There is as yet no standardised approach and the required databases are still under development. The method developed here is based on the ecosystem services valuation categories, definitions and tools provided by the baseline Millennium Ecosystem Services Assessment (Table 3) and these other well-publicised applications:

i) US Center for Neighborhood Technology (CNT) guide for the evaluation of Green Infrastructure (GI)[30]
ii) UK Green Infrastructure North West (GINW), which is being used to promote green infrastructure (GI)[47]

Depending upon context, there are a number of other approaches being used, e.g. for coastal protection in England and Wales.[48] For SKINT the approaches selected have the advantage of having extant databases and recommendations for monetising the multiple benefits of GI and surface water management schemes. New guidance is emerging rapidly and application of the approach should ensure that the latest information is used where practicable. For example, where stormwater alone is being considered, US data and methodologies are now available from CNT;[30] and for UK applications[19] considers the place of ecosystem services in relation to the Water Framework Directive. Drawing on examples, such as in[42], a case is made for a stronger inclusion of ecosystem services analyses into the River Basin Management Planning process that comprises the core of the UK's compliance approach to the Directive.

By adopting a broader approach than simply utilising the core ecosystem services (ES) in Table 3, the SSIS methodology enhances the water aspects of the analytical process. Many ES based approaches are also focused on rural (water) catchments and much of SKINT deals with urban areas. For example, the CBMDC case study in Keighley is in the town, whereas a recent environmental valuation study[49] virtually ignores the built-up urban area in the catchment in the evaluation which is based on ES.

There are also specific sectoral support tools, such as the World Business Council for Sustainable Development's Guide to Corporate Ecosystem Valuation: A framework for improving corporate decision-making[50] and The Economics of Ecosystems and Biodiversity in Business and Enterprise[51] which may be useful for attracting private finance for a scheme.

The two extant valuation tools introduced above are reviewed in more detail in the following sections.

---

[47] Green Infrastructure North West (2011). Building natural value for sustainable economic development – the green infrastructure valuation toolkit user guide Green Infrastructure North West, UK. Go to: *http://tinyurl.com/6wdl53s*

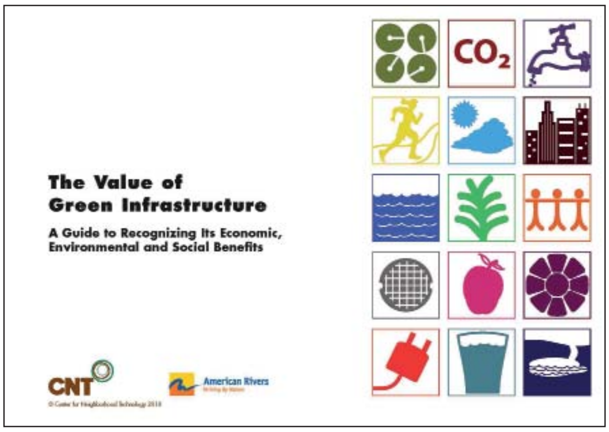
[48] Brouwer, R et al (2010). Flood and coastal erosion risk management: economic valuation of environmental effects. Handbook for the Environment Agency for England and Wales Economics for the Environment Consultancy (EFTEC), London.
Go to: *http://publications.environment-agency.gov.uk/PDF/GEHO0310BSFH-E-E.pdf*

[49] Natural England & Yorkshire Water (2012). Valuing land-use and management changes in the Keighley and Watersheddles catchment. Natural England Research Report NERR044. ISSN 1754-1956 © Natural England 2012

[50] *http://www.earthprint.com/productfocus.php?id=WBCSD0179*

[51] Bishop J (2011) Ed. The Economics of Ecosystems and Biodiversity in Business and Enterprise. Routledge. ISBN 978-1-84971-251-4

### 3.1.2 CENTER FOR NEIGHBORHOOD TECHNOLOGY (CNT) GUIDE FOR THE EVALUATION OF GREEN INFRASTRUCTURE




| Benefit | Reduces Stormwater Runoff: Reduces Water Treatment Needs | Reduces Stormwater Runoff: Improves Water Quality | Reduces Stormwater Runoff: Reduces Grey Infrastructure Needs | Reduces Stormwater Runoff: Reduces Flooding | Increases Available Water Supply | Increases Groundwater Recharge | Reduces Salt Use | Reduces Energy Use | Improves Air Quality | Reduces Atmospheric $CO_2$ | Reduces Urban Heat Island | Improves Community Livability: Improves Aesthetics | Improves Community Livability: Increases Recreational Opportunity | Improves Community Livability: Reduces Noise Pollution | Improves Community Livability: Improves Community Cohesion | Improves Community Livability: Urban Agriculture | Improves Habitat | Cultivates Public Education Opportunities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Green Roofs | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | Yes | Maybe | Yes | Maybe | Maybe | Yes | Yes |
| Tree Planting | Yes | Yes | Yes | Yes | No | Maybe | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Maybe | Yes | Yes |
| Bioretention & Infiltration | Yes | Yes | Yes | Yes | Maybe | Maybe | No | No | Yes | Yes | Yes | Yes | Yes | Maybe | Maybe | No | Yes | Yes |
| Permeable Pavement | Yes | Yes | Yes | Yes | No | Maybe | Yes | Maybe | Yes | Yes | Yes | No | No | Yes | No | No | No | Yes |
| Water Harvesting | Yes | Yes | Yes | Yes | Yes | Maybe | No | Maybe | Maybe | Maybe | No | No | No | No | No | No | No | Yes |

Yes Maybe No

FIGURE 6 CNT GUIDANCE FOR MULTI-VALUE OF GI AND SURFACE WATER (FRONT COVER AND BENEFITS OF GI PRACTICES)

The US CNT method, Figure 6, has been developed because many US municipalities recognised the multiple values of GI in relation to surface water management, there was no established means of estimation or documentation of the benefits,[52] although[30] now provides information in version 2.0 of the "Low Impact Development Rapid Assessment" tool (LIDRA) which purports to give a simplified assessment of the use of GI in relation to storm water management, including costs.[53] Decision-making regarding stormwater infrastructure investments has traditionally lacked recognition of the wider monetary and other benefits that GI/stormwater can provide to communities. The CNT approach has been used for the analysis of the alternative management of stormwater compared with using piped drainage systems in Philadelphia,[54] as illustrated in Figure 7.

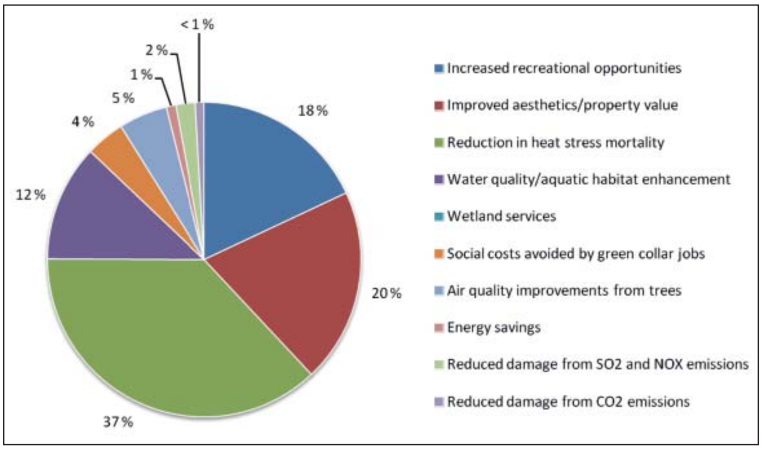



**FIGURE 7. PRESENT VALUE BREAKDOWN OF CITY-WIDE NET MULTI-FUNCTIONAL BENEFITS FROM RETROFITTING GI IN PHILADELPHIA TO MANAGE 50% OF STORMWATER RUNOFF TO CONTROL COMBINED SEWER OVERFLOW SPILLS FOR A 40-YEAR PERIOD**[55]

Using the CNT method, the value of a given set of possible investments is expressed monetarily. Non-market valuation methods include revealed preference methods, stated preference methods and avoided cost analysis. The method is not without flaws – many social benefits are not included and full life cycle analysis is still necessary for large scale planning – but it gives a clearer picture of the multiple benefits of GI that can be used as a template for non-GI interventions as well as GI.[56]

The CNT lists five GI options (green roofs, tree planting, bioretention & infiltration, permeable pavements and water harvesting) and calculates monetary benefits in terms of:

- Water
- Energy
- Air quality
- Climate change
- The urban heat island effect
- Community liveability
- Habitat improvement and
- Public education

This is done in two stages:

1. Quantification of benefits, where a resource unit is defined (e.g. KWh for energy) and
2. Valuation of benefits (where a monetary value is assigned to the benefits).

It should be noted that valuations are not applied to the final four criteria.

---

[52] Ashley, R M, Nowell, R, Gersonius, B., Walker, L (2011). Surface water management and urban green infrastructure – a review of potential benefits and UK and international practices. Foundation for Water Research, Bucks

[53] *www.lidratool.org* (10.08.12)

[54] Neukrug, H M (2009). A triple bottom line assessment of traditional and green infrastructure options for controlling CSO events in Philadelphia's Watersheds. Final report. Office of Watersheds, City of Philadelphia Water Department under contract to Camp Dresser and McKee

[55] The plan is constantly evolving – see *http://www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan*

[56] Here GI = green infrastructure is the SuDS that add 'green' to the urban environment – therefore certain SuDS, such as filter drains or infiltration systems do not add value.

An online calculator[57] is described as follows:

*"The National Green Values™ Calculator is a tool for quickly comparing the performance, costs, and benefits of Green Infrastructure, or Low Impact Development (LID), to conventional stormwater practices. The GVC is designed to take you step-by-step through a process of determining the average precipitation at your site, choosing a stormwater runoff volume reduction goal, defining the impervious areas of your site under a conventional development scheme, and then choosing from a range of Green Infrastructure Best Management Practices (BMPs) to find the combination that meets the necessary runoff volume reduction goal in a cost-effective way."*

The methodology used in the calculator is also detailed.[58] The calculator can be used alongside the evaluation report, but they are not completely aligned as the guidance for evaluation was updated in 2010 and the online calculator dates from 2009. An illustration of the valuations is shown in Table 4.

| GI's benefit | GI component | Value ($) |
|---|---|---|
| Reduced Air Pollutants | Trees | 0.181 per tree |
| Carbon Sequestration | Trees | 0.12 per tree per year |
| Compensatory Value of Trees | Trees | 632 per tree |
| Groundwater Replenishment | Infiltration basins | 86.42 per acre-foot infiltrated |
| Reduced energy use | Green roofs<br>Trees | 0.18 per square-foot of green roof per year<br>5-10% energy savings from shading and wind blocking per 10% increase in tree cover |
| Reduced treatment costs | | 29.94 per acre-foot of reduced runoff |

**TABLE 4. VALUE OF GI COMPONENT BENEFITS FROM THE CNT CALCULATOR**

### 3.1.3 GREEN INFRASTRUCTURE NORTH WEST (GINW) ONLINE CALCULATOR

The GINW approach has been developed to support Regional development agencies in England to better value their GI.[59] The CNT approach considers storm and surface water management in a more intrinsic way than the GINW approach, as the latter includes SuDS and other measures only as a supporting consideration for the promotion of GI. Figure 8 shows the valuation toolkit.

A number of applications of the GINW toolkit have been used in the UK. An indicative economic assessment of interventions at Halewood Primary School (Figure 9) to reduce waterlogging of the playing fields suggested it to be a worthwhile investment for funders, with a net present value of £80,000 over a 50 year period (value of the benefits, minus capital costs and estimates of on-going additional management costs). Three major economic benefits of the work, in addition to the water management, were found:

- Recreation and leisure – £75,000 (in other economic value); increased access for the children to the field.
- Land and property value increases – £22,000 (in GVA); improvements to the school field enhance the setting for houses immediately around it.
- Climate change mitigation – £1,000 (in other economic value); carbon sequestered through the new tree planting.

---

57 *http://greenvalues.cnt.org/national/calculator.php* (accessed 24-04-12)
58 *http://greenvalues.cnt.org/national/downloads/methodology.pdf* (accessed 24-04-12)
59 *www.bit.ly/givaluationtoolkit* (accessed 24-04-12)

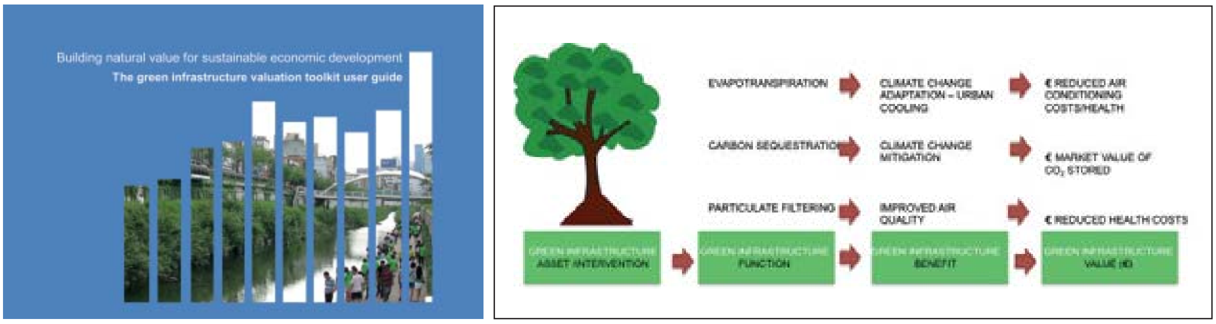



**FIGURE 8. GINW TOOLKIT GUIDANCE AND ILLUSTRATION OF MONETISATION PROCESS USED**

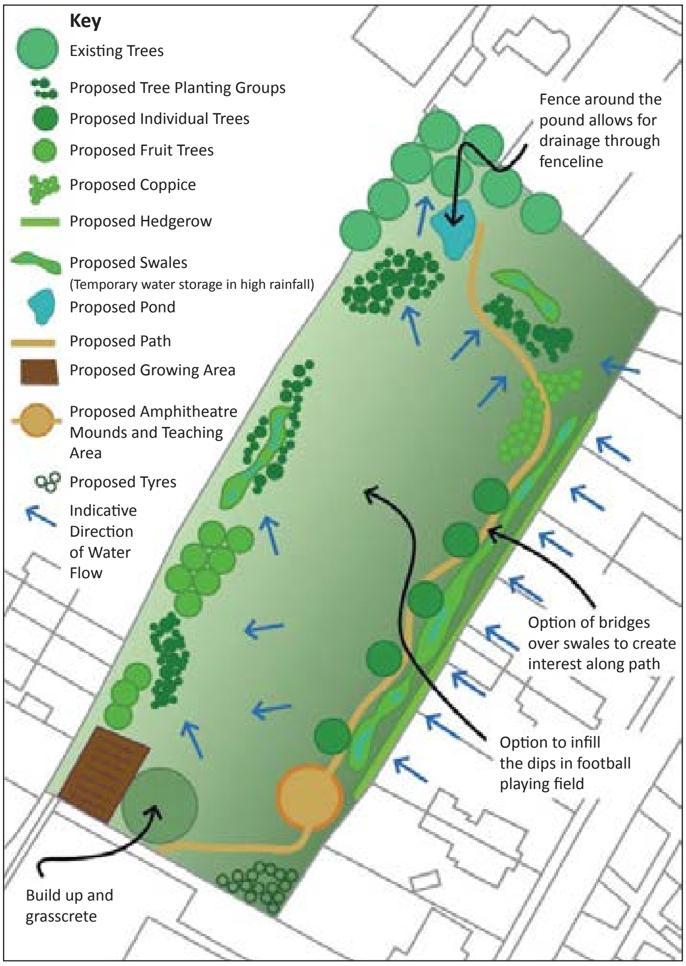



**FIGURE 9. INITIAL DESIGN FOR THE SUDS COMPONENTS AND OTHER LANDSCAPE FEATURES ON THE SCHOOL PLAYING FIELD**

Elements of water management include:

- Hedgerow along the south-western edge as the first area of interception of water flow; tree planting will also further reduce overland flow across the field.
- Swale running along the south-western edge capturing overland flow and channelling this towards the lower-lying (eastern) end of the playing field.
- The swale will be connected via short sections of pipe to a small wetland and a pond (the pond already exists, but has been filled in with rubble which will be excavated and re-used in the construction of other features).
- The swale, wetland and pond areas will be seeded with emergent vegetation, which will increase biodiversity value.
- A footpath will run along the northern side of the swale to the eastern end of the field, permeable and designed to effectively act like a shallow French drain.
- New trees (such as willows and other water loving/tolerant species) will be planted so canopies will capture rainwater and prevent it reaching the ground. In addition, the trees will draw water up from the ground, helping to create drier conditions, and tree roots will help to break up the ground, thereby improving drainage.

The GINW valuation toolbox was originally designed to promote economic development related to GI and uses 11 benefit groups that are mapped on to the ecosystem services categories:

1. Climate change adaptation and mitigation;
2. Water and flood management;
3. Place and communities;
4. Health and well-being;
5. Land and property values;
6. Investment;
7. Labour productivity;
8. Tourism;
9. Recreation and leisure;
10. Biodiversity;
11. Land management.

The benefits provided by each of these groups are defined by specific and in many cases, measurable indicators. Some of these are included in an assessment of the monetised benefits accruing from the use of GI, whereas other indicators may only be considered in a qualitative sense in a comparative evaluation.

The GINW guidance/toolkit comes with a spreadsheet tool which makes extensive use of the value transfer approach, inferring one economic valuation from another. Calculation factors have been adopted based on a “reasonable rules of thumb” approach. Therefore it is important to consider the toolkit outputs as strictly indicative; the calculator does give warnings and guidance where such assumption-based factors are being used. When good local data are available, the toolkit should be tailored by replacing these assumption-based factors with parameters specific to the project.

The toolkit therefore has missing data and is aimed at developments where new GI is being created. It is consequently of limited use for regeneration or retrofits. With its emphasis on GI, the toolkit does not include the entire breadth of ES and there are acknowledged overlaps in the categories, threatening risks of double counting. The toolkit attempts to identify the benefits that can relate to gross value added, those which have a broader economic context and the residual benefits that cannot be monetised but can be either quantified or described. It does not distinguish between economic impacts which relate to economic growth and economic value, which expresses welfare benefits to people in monetised terms, nor does it distinguish between absolute and relative impacts.

The application of these valuation tools to SSIS, in conjunction with Figures 4 and 5, is considered in the following section.

# 4. Application

The CNT and GINW approaches have been adapted for SSIS based on beneficiaries' feedback on these approaches and the likelihood of data availability, and supplemented using specific additional criteria (defined as WP4 specific). The first stage in Figure 4 is the definition of assessment boundaries – what services are the most significant and who should be involved in the assessment?

A matrix of benefits developed jointly with the beneficiaries is shown in Annex 1, categorised in terms of:

- Protection of air/water/planet;
- Flexibility and adaptability to climate change;
- Contribution to local/global economy;
- Life cycle costs;
- Affordability;
- Risks;
- Public/professional engagement;
- Amenity provision;
- Acceptability;
- Media influence;
- Attention to cultural heritage;
- Energy use.

The matrix may be used to support communication, conversations, discourse and for illustrative purposes and also to develop detailed analyses of benefit value in monetary terms. It should be used sequentially at three complementary levels, as illustrated in Table 5. The benefits are classified into 12 categories listed in Table 6.

| | |
|---|---|
| **Level 1**<br>Overview assessment of the likely benefits to: | • Environment (e.g. EU biodiversity strategy)<br>• Economy<br>• Society<br>• Energy use<br>• Cultural heritage. Considered of major importance for certain beneficiaries e.g. Bryggen in Norway<br>• EU Directive fulfilment (overall) – notably the Flood Directive and the Water Framework Directive (but others also need to be considered)<br>• Regulations/Directive necessary for local planning? These will be local context-specific. |
| **Level 2**<br>Quantitative analysis – likelihood of being able to carry this out | • Direct quantitative analysis – possible for physical, chemical, biological benefits and impacts (e.g. via EIA/SEA)<br>• Indirect quantitative analysis possible – to include social, policy, strategy (e.g. green infrastructure strategies, planning processes) |
| **Level 3**<br>Financial Valuation | • Financial Valuation tool availability – mainly comprising financial benefits and costs, but may include willingness to pay (unless included in Level 2 above) |

**TABLE 5. LEVELS AND SEQUENCE OF ASSESSMENT USING THE SSIS MATRIX (ANNEX 1)**

Only where the likely benefits are identified as substantial in Level 1 should the Level 2 and 3 assessments be considered. A separate spreadsheet for the matrix, including a doughnut benefit illustrator, is provided separately for Level 1 analysis.

| Category | Explanation |
|---|---|
| Protection of air/water/planet | This includes impact criteria, including resource depletion and also enhancements such as increasing biodiversity and pollination. |
| Flexibility and adaptability to climate change | The application in SKINT relates to the water cycle and how this can accommodate climate change. |
| Contribution to local/global economy | Includes provisioning and regulatory services as well as job creation. |
| Life cycle costs | Value for money over entire life of project |
| Affordability | Relates to investment regimes and security of long-term funding. |
| Risks | Risks may be interpreted variously; here they relate to the security of the scheme in providing adequate performance and can include robustness. |
| Public/professional engagement | Aims to ensure the highest levels of engagement from all stakeholders |
| Amenity provision | Increasingly, there is a desire to enhance amenity value, in urban areas especially |
| Acceptability | By communities, but also longer term e.g. as an exemplar pilot project |
| Media influence | In many countries reputational aspects are particularly significant, especially where cultural heritage is concerned |
| Attention to cultural heritage | A very important category in SKINT, it applies to human values as well as to the preservation of artefacts and historic assets |
| Energy use | Here this applies mainly to added values from using water to improve urban environments by taking an integrated approach |

**TABLE 6. BENEFIT CATEGORIES**

Where local data are not available, the US, UK and other data sources can be used and adapted to wider European application. In this way, the multiple benefits of water management options can be better quantified based on criteria collectively determined to be important within SKINT. This will include cultural heritage. The European Convention on the Protection of Archaeological Heritage, the Valletta Treaty, is an initiative from the Council of Europe from 1992, aiming to protect European archaeological heritage *"as a source of European collective memory and as an instrument for historical and scientific study. All remains and objects and any other traces of humankind from past times are considered to be elements of the archaeological heritage. The archaeological heritage shall include structures, constructions, groups of buildings, developed sites, moveable objects, monuments of other kinds as well as their context, whether situated on land or under water."* Cultural heritage is a mixed good, framed over a multidimensional, multi -value and multi -attribute environment, generating private and public/collective benefits for current, potential, and future users and even for nonusers.[60]

The SSIS matrix therefore includes a multidisciplinary framework for the assessment of cultural values as a response to the complex, multifaceted, and multivalue nature of cultural heritage and impact that water management has on its' preservation. Economic instruments should be used as complementary means for socioeconomic analysis, together with a range of other tools from various disciplines. Measuring cultural benefits/values in this context should therefore be the output of a multidisciplinary (or preferably, transdisciplinary[61]) team that includes not only economists and conservation specialists but also other scientists and specialists.

Annex 2 examines each of the criteria in the matrix individually.

The participants in the process may vary between each of the three levels. Ideally, as wide a range of potential stakeholders (defined as those affected either directly or indirectly) should be engaged in the analysis at each of the three levels. However, it is recognised that wide engagement of all potential stakeholders is problematic and challenging, often resulting in stagnation of development or change process proposals, especially in relation to land use change; who should be involved will therefore vary between locales[2]. Nevertheless, appropriate engagement is important and enshrined in EU Directives, the most relevant of which is the Water Framework Directive which sets out balancing land use and water management, but also challenges the institutional arrangements within which it has to be delivered.[62]

The HarmoniCOP (Harmonising Collaborative Planning) EU project had the objective of setting out how to effectively engage appropriate stakeholders in catchment-related decision making.[63] An alternative, the Learning Alliance approach, was studied in the later EU SWITCH project where learning groups were used in international cases as the main vehicle for delivering sustainable water management.[64] However selected, stakeholders should review the criteria with the support of the promoters of any project and engage in the completion of the matrix.

---

60 Mourato and Mazzanti (2002) Economic valuation of Cultural Heritage: Evidence and Prospects. In: Assessing the Values of Cultural Heritage, Getty Conservation Institute, Los Angeles (2002) 51-76; Vaz et al (2012) Urban heritage endangerment at the interface of future cities and past heritage: A spatial vulnerability assessment. Habitat International 36 (2012) 287-294.

61 Max-Neef M (2005) Foundations of transdisciplinarity. Ecological Economics 53. 5– 16

62 Moss T. (2004) The governance of land use in river basins: prospects for overcoming problems of institutional interplay with the EU Water Framework Directive. Land Use Policy 21 (2004) 85–94

63 Learning together to manage together – improving participation in water management. *http://www.harmonicop.uni-osnabrueck.de/* HarmoniCOPHandbook.pdf (accessed 10-08-12) (EU 5th FP project 2002-2005)

64 Butterworth, J., McIntyre, P., da Silva Wells C. (2011): SWITCH in the city: putting urban water management to the test. ICR International Water and Sanitation Centre. ISBN 9789066870789. *http://www.switchurbanwater.eu/*

# 5. Using the Matrix for SSIS

## 5.1 OVERVIEW

The matrix (Annex 1) is designed to assist in the identification of benefits from any proposed scheme. At Level 1 the potential for benefits to accrue can be highlighted by marking these as likely to be "H". A spreadsheet can be used to collate these ratings to produce an illustrative image showing mainly high or positive benefits. Level 2 helps to identify whether or not a more detailed physical, chemical, biological, social and environmental analysis is possible and will depend on data availability. The Level 3 analysis here is simply a tick-based evaluation of whether or not financial or economic assessments are likely to be possible. Annex 2 provides information defining the benefit criteria and what might be possible using the CNT, GINW and other tools.

SSIS may be based on the alternatives, or collective results of application of the matrix. A Level 1 analysis alone can be used to illustrate to decision- or policy-makers that the proposed scheme has significant added value, over and above the main objectives of e.g. flood or water pollution control, as illustrated in Section 6. At higher levels the increasing details from the analyses provide the means to define e.g. the contribution to reductions in water pollution for specific pollutants or added benefits to society of creating GI (Level 2) and the estimated financial value accruing from doing this (Level 3).

Applications in SKINT visual presentations, as illustrated in Section 6, deal with initial subjective assessments by learning alliances or groups of stakeholders. In WaterTown visualisation may potentially utilise the monetised benefits; however, this was considered to be too detailed, and in any case would provide unrealistic perceived precision based on the limited contextual information – e.g. "this intervention would have added value benefits over and above those of flood risk management of €XXX". This would require estimation of the monetised benefit analysis of the options available in WaterTown. An alternative would be to utilise a scale, or light system, based on the relative numbers of added benefits accrued by the option(s) selected by the game player. Therefore if, in the matrix, the option contributed to many of the listed benefits, the game could show a "many added benefits" rating. If, however, few of the benefits were realised by the option (it is unlikely there would not be any), the rating would be "few added benefits". The former could be a green light and the latter a red light. There could be an amber light for "some" benefits. There may be a need to weight the benefits, as some are clearly of greater value than others; however, this may not be realistic without the context in which the ratings are set.

Application of the SSIS approach brings together the ecosystem services valuation scheme shown in Figure 4 and the benefit-cost approach in Figure 5. At Level 1, the assessment is subjective and lacks detail. Level 2 provides an indication of how detailed a further analysis at Level 3 could be in assigning direct monetary benefits to each of the criteria in the matrix, following a Level 1 assessment that indicates that such an assessment is likely to be worthwhile or not.

## 5.2 OBJECTIVES AND CONSTRAINTS

It is important before undertaking any assessment to firstly define the objectives of the scheme – the problems to be solved and/or the opportunities to be taken. A clear statement of objectives then allows the full range of options to be identified. It is also important to define the potential constraints and assumptions. The FloodProbe project[65] has considered the economics of multi-functional flood defences and the following outline is adapted from the outcomes of that project.

Examples of some of the possible constraints to restrict the alternatives to be considered (USDOHAH, 2012):

- Laws and regulations – for example, regulatory agencies may require specific design approaches for new systems or mandate specific changes to existing systems;
- Technological – for example, new equipment must be compatible with existing equipment;
- Socio-political – for example, the Governor mandates certain functions to be combined with the dikes because of additional risk types;
- Financial – for example, proposed development and implementation costs must remain within a specified budget;
- Operational – for example, space, staffing levels, skill mix, and capability and competence factors may limit system options;
- Environmental – for example, environmental protection standards which must be met.

As defined by the UK Green Book,[66] constraints could be inter alia financial, managerial, political, distributional, institutional and environmental. However, the US Department of Health and Human Services (USDOHAH, 2012)[67] expresses some of the possible constraints as shown in the box below.

For the SSIS approach, the constraints above need to be considered, together with the assumptions. The latter will relate to the vision of the need to manage water in the urban environment differently from the approach of the past, linking to land use, urban design and planning and maximising value as far as practicable.

Various alternative options should be defined covering different approaches; although these alternatives may represent what seem to be opposing strategies, they then provide a better scope for decision-making. However, generating and analysing a large group of alternatives can be very expensive and time-consuming and a screening process is needed to reduce these in scale.

## 5.3 MULTIFUNCTIONALITY AND COSTS

Normally, the initial alternative in a benefit-cost analysis is “do nothing” or maintain the status quo as the reference point for relative evaluation of the performance of other alternatives. Furthermore, defining the “do nothing” is necessary to evaluate what might occur if the project had not been conceived. In the case of multifunctional flood response measures such as flooding recreational areas, the status quo may refer to the current flood risk without implementing any mitigation measures.[68]

In SSIS, there is likely to be a need to determine the value of adding at least one secondary function to a water management system. The alternatives could be as follows:

1. The “do nothing” alternative.
2. Improving the water management system without adding any extra function. This alternative can be a combination of various measures depending on whether it is solely for flood risk management, or also includes water quality.

---

[65] *http://www.floodprobe.eu/* accessed 10-08-12
[66] HM Treasury (2011) THE GREEN BOOK Appraisal and Evaluation in Central Government. Update from 2003. UK.
[67] U.S.D.O.H.A.H. 2011. State Systems APD Guide : Feasibility Study and Alternatives Analysis [Online] [Online]. Available: *http://www.acf.hhs.gov/programs/cb/systems/sacwis/cbaguide/c2fsaa.htm*
[68] E.g. Kunreuther, H., Cyr, C., Grossi, P. & Tao, W. (2001). Using Cost-Benefit Analysis to Evaluate Mitigation for Lifeline Systems. *http://opim.wharton.upenn.edu/risk/downloads/archive/arch90.pdf* accessed 10-08-12

3. Improving the water management system with extra functions. For this, the secondary functions may include provision of recreation facilities in new blue infrastructure areas – sailing, watersports etc. Implementing this alternative aims to provide additional benefits in addition to risk reduction. The options can cover various types of functionality that can be constructed concurrently with the water management responses.
4. Integrating extra functions into the water management system. This alternative proposes to use the water management responses in such a way that they not only provide greater safety but are also as an efficient means to build in other functionalities, which increase e.g. amenity values through the use of green infrastructure.

Identifying the costs can start with the impact assessment process which should include the associated advantages and disadvantages of implementing each alternative. Costs must be assigned to as many of the cost items as possible for the whole lifetime of the project and include decommissioning. There are many guidance documents setting out how to do this[69] in the various domains of interest.

Costs should be classified[63,65] into fixed costs, variable costs, semi-variable-costs and semi-fixed or step costs as illustrated in the box below. In this, sunk costs should be avoided in any interpretations in such cost analyses because these have already been incurred and are irrevocable. *"Sunk costs are costs incurred in the past in connection with the proposed project. However ill – advised they may have been, such costs have already been incurred and can no longer be avoided. When analysing a proposed project, sunk costs are ignored (…) it is not valid to argue that a project must be completed just because much has already been spent on it. To save resources, it is preferable to stop a project midway whenever the expected future costs exceed the expected future benefits."*[70] Economic and financial analyses consider only future returns to future costs.

The negative costs can be counted as benefits or deducted from the total cost of the project.

Types of costs:

- Fixed costs remain constant over wide ranges of activity for a specified time period regardless of the level of output of the activity. Examples are rents, rates, insurance costs.
- Variable costs vary according to the volume of activity and in direct proportion to output. There is a clear unit of input for every unit of output. Examples are material and labour costs.
- Semi-variable costs include both a fixed and variable component. This assumes that a significant portion of costs are fixed, although there is degree of variability in the output. Examples are maintenance and transportation costs.
- Semi-fixed, or step costs are the costs that remain fixed for the purchase of certain numbers of a product, but then jump drastically when greater numbers are required. Step-variable costs are named for how they appear when graphed.

A recommended starting point to identify costs is to distinguish between those costs incurred only at the start of the intervention, and whose benefit lasts for more than one year (termed "investment" costs), and the costs that recur every year (termed "recurrent" costs).

In addition to the cost of water systems improvement, a similar procedure needs to be followed to determine the costs of any extra functions added to the primary response. Except for the alternatives integrating secondary functions into the water management system (4 above), for the other alternatives, the cost evaluation process needs to be made separately for the water management system and the additional secondary functions. This makes it easier to use any available standardised unit costs for the 'standard' water system management improvements. There are unlikely to be any unit costs that can be applied to the combined system of water management with extra functionality/benefits, and these have to be dealt with separately. It is also simpler to compute the costs separately as they could have different expected lifetimes.

## 5.4 BENEFITS AND COSTS

Benefit evaluation should consider whether the benefits of implementing alternative options are worth their costs. Assessing the benefits is more complex than the costs as the benefits cover a wide range of aspects (addressing economic losses, injuries and casualties, psychological trauma, ecosystem diversity etc.), impacting on people in different domains and also occurring at different times in the future.
In addition to the direct water management benefits of an intervention, it is necessary to deal with the benefit assessment of adding additional functions. Two perspectives need to be considered for the evaluation of the extra functional benefits: the economic evaluation of e.g. ecosystem services and additional factors as defined in the CNT type of approach,[30] which may or may not include market price valuation. The purpose of ecosystem valuation methods is to estimate the economic value of changing the baseline environment present in the area or to assess the amenity and recreational value of extra functions, if any. Market price evaluation methods consider the services provided by the property and any other assets located on/around the water management system. Approaches such as that of CNT and GINW, purport to include many of the ecosystem services as well as market price support tools. However, so far there are only limited applications of fully detailed and comprehensive benefit valuations and those that are available apply to limited areas, such as flood risk management linked to ecosystem services.[71]

The standard approach to valuing costs and benefits that occur at different times is based on the assumption that money held now is worth more than it will be in the future. Discounting converts all costs and benefits that occur in different time periods to "present values", so that these can be compared. The discount rate is equivalent to the average return expected if the money was invested in an alternative project. The present value of the stream of benefits is the sum of all annual benefits, with each annual benefit discounted by the appropriate discount rate (r) to convert it into present value terms. A fixed discount rate is used to represent the opportunity costs of using public funds for the given project. Br denotes the annual net financial cost or benefit:
Present value of benefits = $\sum_{r=0}^{T} \frac{B_r}{(1+r)^t}$

The net present value is the primary consideration for recommendation and decision making in project evaluation concerning cost efficiency. The total cost of the project each year over its lifetime is subtracted from the total benefits in each year to yield net benefits per year. The NPV takes the net benefits (benefits minus costs) each year and discounts these to their present day value. If the result is greater than zero, this indicates that the benefits outweigh the costs; the higher the value, the greater the financial argument for initiating the project. Life cycle costs are defined as the sum of the present value of the investment costs, capital costs, installation costs, operation and maintenance costs and replacement and disposal costs over the lifetime of the project. Life cycle benefits represent the present of the accrued benefits over the lifetime. The life-cycle net benefits provide the Net Present Value (NPV) = PV benefits – PV costs. Thus the NPV can show that a scheme with higher initial investment costs can yield greater benefits over the lifetime of a project.[72]

---

[69] E.g. APFM Technical Document No. 5, Flood Management Policy Series © World Meteorological Organization, 2007 ISBN: 92-63-11010-7. *http://www.apfm.info/pdf/ifm_economic_aspects.pdf* accessed 10-08-12
[70] Belli et al (1998) Handbook On Economic Analysis Of Investment Operations. Operational Core Services Network Learning and Leadership Centre. World Bank. *http://siteresources.worldbank.org/INTCDD/Resources/HandbookEA.pdf* accessed 10-08-12
[71] E.g. Eftec (2010) Flood and Coastal Erosion Risk Management: Economic Valuation of Environmental Effects. FCERM: Economic Valuation of Environmental Effects - Handbook. London, UK: The Environment Agency for England and Wales.
[72] Thurston H W et al (Ed.) (2012) Economic incentives for stormwater control. CRC Press. Taylor & Francis. ISBN 978-1-4398-4560-8

# 6. Matrix Applications in SKINT

The matrix in Annex 1 has been applied to the SKINT case study interventions using a spreadsheet model. Each of these interventions is presented in the following sections. Various formats were trialled for the graphical presentation of the results. Initially a doughnut or dartboard type plot was favoured; however, as there are 39 criteria in 5 benefit areas, these images were found to be too crowded for rapid scanning and a bar chart was selected which has blanks for "no" benefit or "inapplicable" regarding benefits. These plots can be used to illustrate the relative benefits of the options in a way that is readily visible to decision- and policy-makers. The horizontal scale covers the 5 benefit areas of environment, economy, society, energy use and cultural heritage. The coloured bars in each assessment are categorised as:

**Red** for low benefit
**Blue** for medium benefit
**Green** for high benefit

Thus where all five of the benefit areas are assessed to receive benefits from the scheme proposed, there will be a continuous horizontal bar. Where all the benefits are "high" this will be entirely comprised of a green colour. Only one of the case studies shows this: there are five benefit categories denoted green for security of funding for Bryggen (Figure 12). Usually the bars are comprised of the different colours, indicating a mixture of low to high benefits expected. Gaps indicate no benefit. There is no significance to the order of the coloured bars, although these do reflect the order of the benefit categories, but where there are no benefits in a category, the sequence of the coloured entries in the bars does not show which categories have no benefit.

Where no benefit has been assigned, this may mean "not relevant" to the particular case example or context and should not necessarily be interpreted in a negative way.

Each of the case studies outlined in the following sections is described in detail in Volume 1 of the SKINT Water Series. Here only a summary is provided as an introduction to each.

## 6.1 FLOOD ALLEVIATION AT DEVONSHIRE PARK AND MAYFIELD ROAD, BRADFORD, WEST YORKSHIRE, ENGLAND

Several flooding incidents over recent years have caused considerable concern over flooding in the vicinity of Devonshire Park. Apart from the physical damage, local citizens suffer from the mental stress each time it rains, especially when thunderstorms are forecast in summer, even though a forecast of a storm does not necessarily mean that flooding will occur. There is a long standing history of flooding in the area; however the perception amongst residents is that both the frequency and intensity is increasing.

The rationale (objective) for the design for Devonshire Park and Mayfield Road is to utilise the full capacity of the surface water drainage system which runs through the area and to store excess flows from Devonshire Park and Mayfield Road when the capacity is exceeded. The reality of this is that the greater the flow that can be passed down the culvert, the less the storage requirement. However, the culvert serves an area larger than Devonshire Park and Mayfield Road and in the long term, its capacity should be apportioned across the whole area that it serves. Storage in the form of SuDS was provided in Devonshire Park using a series of "trench trough" structures. These take the form of troughs or depressions (swales) with gently sloping sides, set over trenches containing underground infiltration tanks or infiltration trenches with high void space.

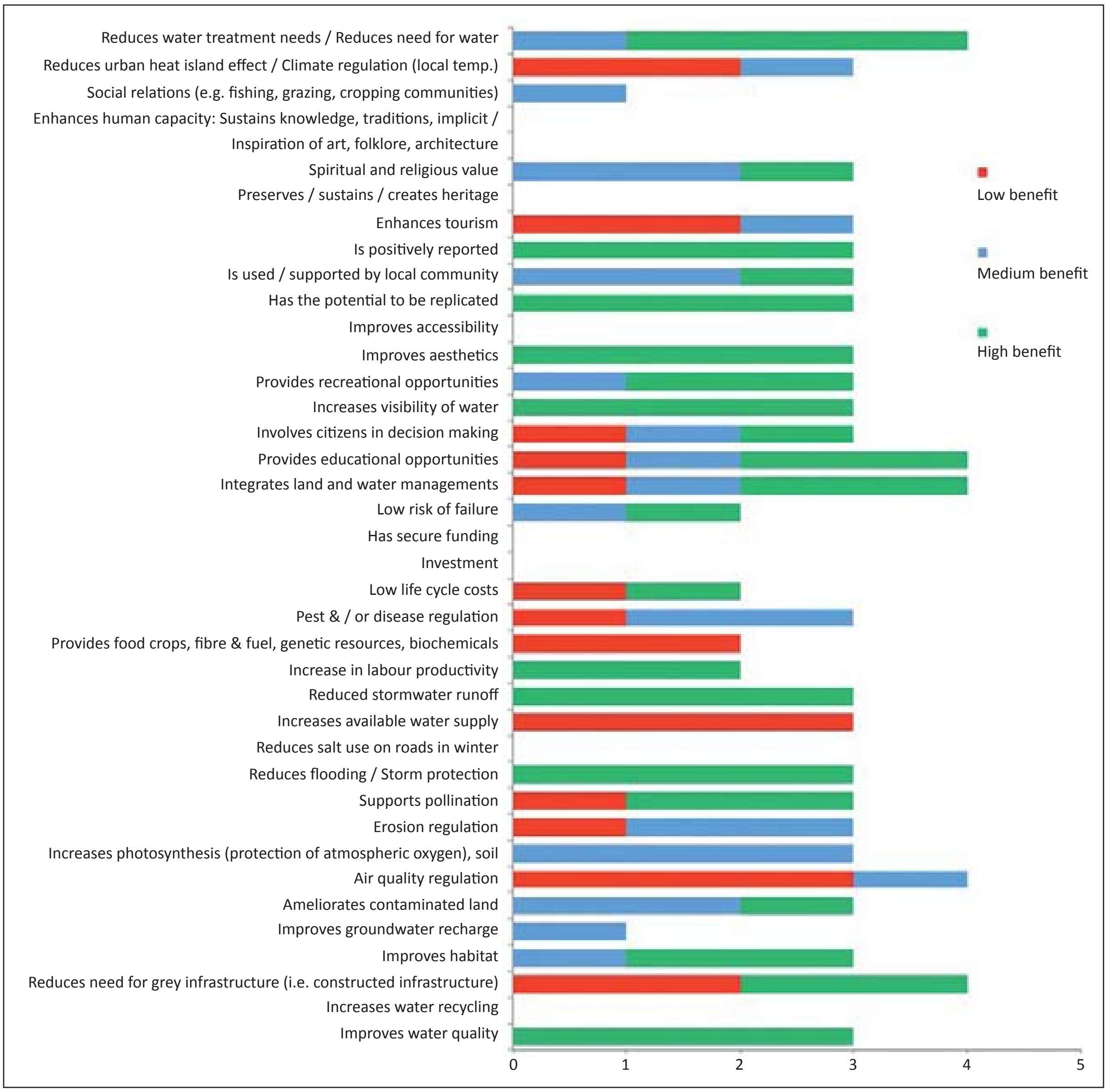



**FIGURE 10. FLOOD ALLEVIATION AT DEVONSHIRE PARK AND MAYFIELD ROAD**

Figure 10 shows the scoring for the first stage of the benefits matrix applied to this case study. The results for this existing but retrofitted scheme indicate mainly no or low perceived benefits from a number of criteria, with high scores only for: educational opportunities, low risk of failure, integration of land use planning and water management, security of funding (scheme already constructed), reductions in runoff and medium to high scoring for flood risk reduction. There are no perceived benefits to reducing heat island effects (the scheme is on the edge of the urban area), social relations, spiritual and religious value, tourism, accessibility, increasing recreation (the scheme is retrofitted to an already green area), visibility of water systems (there could be some standing water when it rains), pest/disease regulation, provisioning services, increase to water supply availability, pollination, improving photosynthesis (although conceivably by holding back the water by increased infiltration this could be enhanced indirectly), air quality, contaminated land alleviation, or water recycling.

There were stated potential benefits for WFD, the FD and in overall reduced flood risk and involving citizens. By promoting green infrastructure there were also perceived benefits regarding the Habitats Directive.

The narrative for sustainability assessment given in Volume 1 of the water series states that the main aim of the chosen options was to alleviate known flooding problems, reducing economic damage to local communities and improving the well-being of community members. This was achieved at no detriment to the local environment and minor improvements were made to the amenity value of Devonshire Park by reducing the water-logging of the ground and hence enhancing its value to the community. Other benefits in terms of sustainability were found when comparing the impacts of the chosen option with those of the alternatives, all of which required considerable disruption within the local communities either through work to be undertaken to provide storage or disconnect surface water drainage within properties or wide scale sewer capacity enhancements. In addition to the disruption, the alternative solutions would have required much greater administrative and community engagement inputs because of the number of people and organisations that would be affected by the solutions and involved in the works. Also, the alternatives, such as the use of grey infrastructure, would have involved significantly greater costs in terms of materials and reinstatement. Hence the chosen option was both socially and economically more sustainable.

Notwithstanding these comments, the matrix has revealed that were a multivalue/beneficial scheme desired at the time the actual scheme was being designed, a number of additional benefits could have been identified from the list of criteria and an alternative solution could potentially have realised several of these. One simple example would be to ensure access to harvesting the stormwater infiltrated from the underground storage. This water could be used to supplement supplies for irrigating the park in times of water shortage – as occurred in early 2012 in England.

## 6.2 DRAINAGE IMPROVEMENTS TO FACILITATE EXPANSION OF EASTERN DUNFERMLINE, SCOTLAND

This was a new development located within an area of what was formerly predominantly greenfield land, comprising some 350 hectares on which 3500 houses, schools, commercial and industrial areas were to be developed over a ten-year period. The 1994 development plan envisaged significant economic regeneration as a benefit of the scheme. The site master-planning coincided with the emergence of ideas about new "green" technologies for managing surface water drainage in the UK. These were being actively promoted by the Environmental Regulator; the principal driver for this was the Water Framework Directive (2000/60/EC). This new surface water management process would come to be known as sustainable urban drainage systems (SUDS) in Scotland.[73] The development was one of the first large-scale applications of SUDS in the UK, although it also includes piped drainage systems where appropriate. The location of the individual SUDS within each catchment, which comprise predominantly green infrastructure, was carefully considered so that they would provide attractive features, integrating within public open space (both parkland and residential areas). These were designed so that they could be accessed and enjoyed by local residents. Safety was perceived as an issue and where SUDS, particularly ponds, were located in close proximity to housing they were designed so that they were overlooked by houses or public roadways so that anyone in difficulty could be easily seen from the houses or public areas.

For maintenance purposes, the municipality adopted the sustainable road drainage systems for the site (including many swales and detention basins) and two SUDS: a wetland and the landscaping area of one pond.

---

[73] "SUDS" is still the terminology in Scotland, whereas England has chosen to drop the "urban" and use the term 'SuDS' to represent 'Sustainable Drainage Systems'.

All adopted structures have public obligations in that the wetland is the central attraction of a district park and the pond has been implemented at a location where municipality-owned homes already existed, and all swales and basins are in public open space. Developers either continue to maintain the remaining SUDS within their ownership or contract the work to factoring agents. There are also a small number of SUDS (and surrounding public open space) which have been legally transferred to private owner maintainers within the site.

Figure 11 shows the scoring for the first stage of the benefits matrix applied to this case study. There were a number of highly beneficial criteria in relation to the development as a whole. Control of flooding followed by improvements to water quality were the primary objectives, although the "cultural heritage" aspects of this were not considered relevant in the context of this case example. The measures were designed to attenuate runoff and address diffuse pollution issues in the receiving water course. Enhanced visibility of water, its aesthetics and demonstration value provides strong additional benefits to the area. There were potential

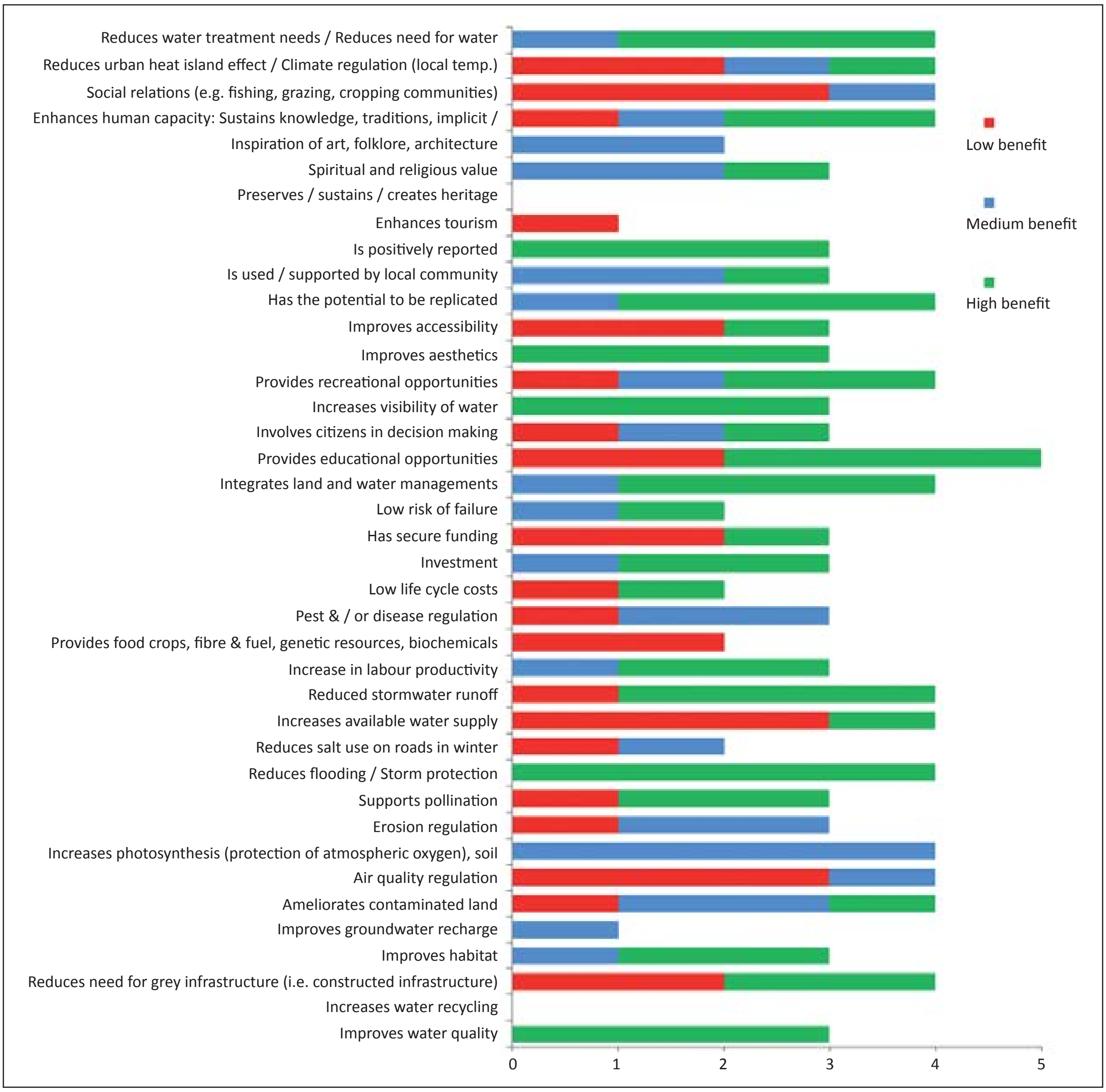



**FIGURE 11. DRAINAGE IMPROVEMENTS TO FACILITATE EXPANSION OF EASTERN DUNFERMLINE**

benefits from a reduction in the need for grey infrastructure, some amelioration of contaminated land, with the increased green infrastructure providing some degree of pollination benefits, improved labour productivity, educational benefits, co-management of land and water, increased human capacity, accessibility, security funding, investment, and recreational. Generally the development has received positive media reporting and also adds spiritual value for the local communities. There are no obvious benefits assigned to preserving or sustaining heritage, tourisms, food crops, fibre & fuel and water recycling.

In the assessment there were recognised benefits in relation to the habitats, groundwater and drinking water-related directives.

In Volume 1, the sustainability assessment states that at the time the drainage issues of DEX were first considered (about 1992), the extent that SUDS were sustainable was not known. However, what was certain was that the problems caused by inadequate urban drainage systems were not compliant with the emerging legislation (Water Framework Directive). It was clearly not socially or economically acceptable to continue to pollute a major estuary which supported a salmonid fishery and contact-based water sports through badly operating combined sewer overflows or diffuse pollution. The environmental regulator led a policy drive to address the problems of diffuse pollution in a more sustainable way.

Rather than focus merely on drainage issues, DEX was seen as being a showcase to encourage greater sustainability in a wide range of construction and development activities. It was a requirement of planning approval to monitor DEX as a large scale test site which would be intensively monitored by a range of universities to try to establish the extent to which the new drainage systems were sustainable. In this way, the full range of sustainability issues – environment, economy, responsibility, social value – could be evaluated in the long term. Knowledge gained from the design and implementation, and importantly the post-project monitoring, has since informed legislation and current best practice for SUDS within the UK.

## 6.3 BRYGGEN IN BERGEN, NORWAY

Since 2001, an intensive monitoring scheme at the World Heritage site of Bryggen in Bergen has shown damaging settling rates caused by deterioration of underlying, man-made deposits. Low phreatic groundwater levels caused by redevelopment of the area next to the heritage site in the late 1970s has led to an increased flux of oxygen into the subsurface. This currently threatens the 61 buildings and historic foundations on the heritage site due to decomposition of organic material and consequent settling. A large restoration project has been running since 2001 to be completed by 2031, covering all of the buildings and their foundations. Currently, the biggest problem is to stop the loss of groundwater towards the redeveloped hotel area next to Bryggen.

Preservation of Bryggen requires a stable hydrological environment, hence groundwater conditions that are favourable for the preservation of archaeological remains and minimal impact of flooding on the above-ground heritage buildings. It is thus necessary to consider the whole urban water cycle at different time and spatial scales. The potential solutions are all based on creating a hydrological division between the hotel area and the heritage site, ranging from improving and extending the existing sheet piling wall to hydrological controls to actively control ground- and surface-water flow. In close cooperation with Bergen municipality, restoration and improvement of the stormwater and sewage system at the upstream area of Bryggen is being done in such a way that it will not damage Bryggen, but instead creates opportunities to increase infiltration rates. SuDS with infiltration facilities are considered as the favoured technical solution that can give opportunities to stabilise the water balance at Bryggen. SuDS are being implemented in two phases. The first is the construction of quick-wins, which are easy-to-implement measures in the area where it is most needed. Infiltration facilities are also being implemented and important knowledge exchange is being achieved through monitoring, workshops and fieldtrips.

Figure 12 shows the scoring for the first stage of the benefits matrix applied to this case study. It is clear that the case generally scores low in category 1, Environment, whilst scoring highly on almost all the other benefit categories of Economy, Society, Energy Use and Cultural Heritage. These high scores are a result of the assessment boundaries being set at a broader level than simply for the technical solutions (SuDS) themselves. Although sustainable water management solutions are being implemented on a local scale, the biggest benefit is the safeguarding of the World Heritage Site Bryggen: a global benefit. In this way valuable cultural heritage is preserved, with broad benefits for the local, regional and national economy and global society as a whole.

There are only a few non-beneficial criteria: pest/disease regulation.

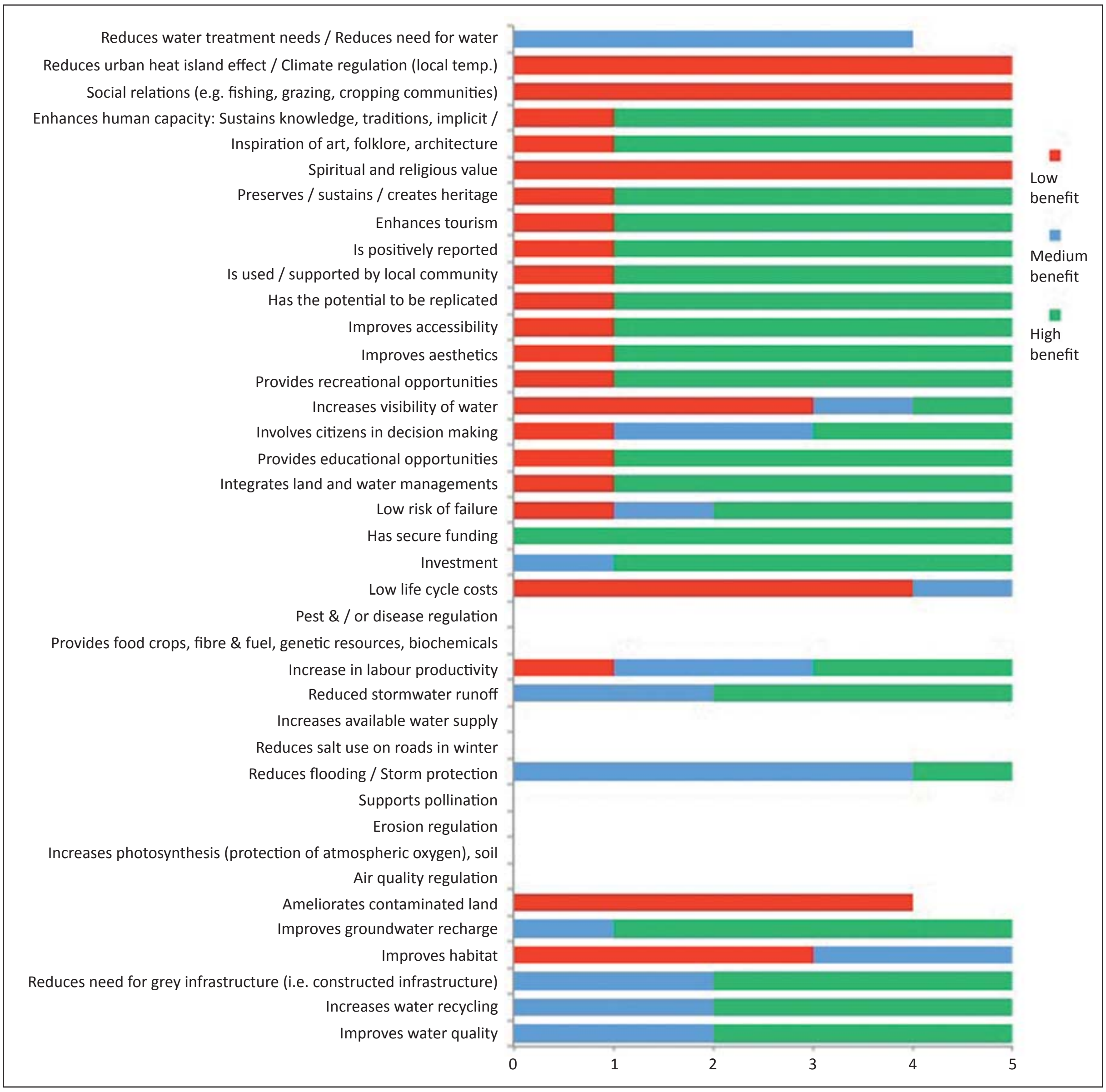



**FIGURE 12. BRYGGEN IN BERGEN BENEFITS MATRIX**

With regards to EU regulations (overall), the options have multiple benefits to several of these. For Bryggen, the overall benefits are not (only) related to WFD or FD, but mostly to the Malta Convention (a European Convention, revised in 1992). National legislation on Cultural Heritage (without it, nothing would happen) and local legislation, such as municipal regulation plans providing protection and opportunities for implementation of SuDS or other sustainable measures are also addressed by the option selected.

The sustainability overview in Volume 1 indicates that as Norway's Directorate for Cultural Heritage, Riksantikvaren, comes under and reports to the Ministry of the Environment, endeavouring to realise the government's national targets for cultural heritage is one of the Directorate's foremost tasks, with sustainability as one of the keywords especially as the origins of the concept in a European context had Norwegian roots.

Archaeological deposits were classified in a Norwegian Report to the Storting as a "non-renewable resource", and are thereby eligible for sustainable management. Raising the level of general awareness of the historical value of the Bryggen remains is a good place to start in order to reduce the loss of cultural heritage, much of this loss being the result of unwitting actions rather than malicious intent. With greater awareness and knowledge there is a much better chance of achieving the national target that the annual rate of loss of protected archaeological heritage is not to exceed 0.5 %.

Through its ratification of the Valletta Convention, Norway has undertaken to "implement measures for the physical protection of the archaeological heritage by making provision for the conservation and maintenance of the archaeological heritage, preferably in situ", otherwise through archaeological excavations and documentation. The Faro Convention – The Council of Europe's Framework Convention on the Value of Cultural Heritage for Society – was ratified by Norway in 2008. Important elements in this convention include the right of every ethnic grouping to have its cultural heritage preserved, the sustainable use of cultural heritage in the development of society, universal right of access to cultural heritage, and the democratic management of cultural heritage.

Strategic central principles are thus in place for the management of all kinds of archaeological heritage, irrespective of age or location. The Norwegian world heritage sites are to be managed in a satisfactory manner and are to be given formal protection through legislation. Restoration and/or maintenance work is on-going at all seven world heritage sites, none of which is in an optimal state of maintenance.

## 6.4 HEUCKENLOCK NATURE RESERVE – A HAMBURG CASE STUDY, GERMANY

The area of Heuckenlock is a nature protection area in the south-east of Hamburg. Due to its function as a nature protection area it mostly benefits the environment. The main aim in developing the nature reserve is to maintain its natural vitality and to restore disturbed sections. A number of water management solutions have been applied, such as lowering of the bank revetment in order to encourage the formation of further inlets and natural and diverse river banks. In order to restore a flow diversion away from the main river, the Heuckenlock tideway has been extended and is again connected to the Elbe on both sides, which it is hoped will reduce silting in the tideway.

Remains of old bank reinforcements have been removed and deep-water drums have been dredged at a depth of 1.5-2 m. Increasingly higher flooding has made it necessary to strengthen and raise the level of embankments. It was initially agreed between the environmental and building authorities to leave out the section of the embankment situated in the nature reserve in order to examine further the possibility of shifting it towards the river so as to reduce floodplain encroachment to a minimum. However, against this agreement, the turf was removed over the full length of the embankment on the nature reserve, and it was only after the environmental authorities intervened that the works in question were suspended. In view of the fait accompli this resulted in and the need to complete the embankment before the winter, the works were continued. Nevertheless, a steeper embankment with a paved exterior was built in the Heuckenlock in order to protect the floodplain.

Although embankment construction was not subject to compensation measures under the (legally contested) Hamburg Nature Protection Act, the authorities agreed to act in accordance with the impact rules as part of the programme to raise the Elbe embankment. The replacement of embankments planned as a substitute measure at other locations was only partially implemented, primarily because of legal problems, which meant that there was a deficit of compensation measures.
The location is a tidal mud flat and water quality as well as water quantity are important factors. Especially flooding and storm protection, but also water supply and stormwater runoff play an important role in adaptation to climate change. The water quality of the Elbe is still not of appropriate standard, and there is

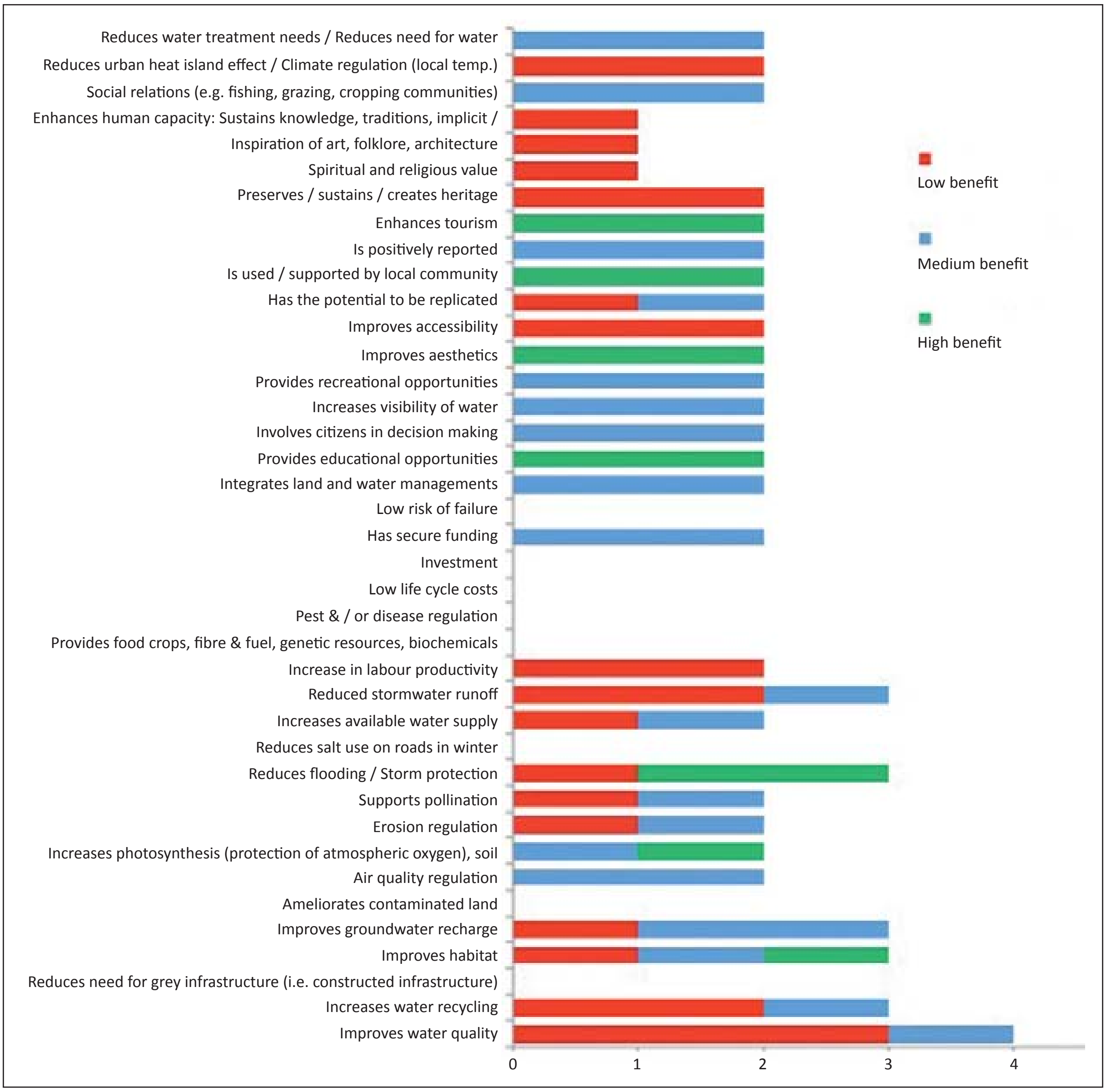



**FIGURE 13. HEUCKENLOCK NATURE RESERVE**

large-scale washing-up of refuse with the tide, which gets caught in the lush vegetation and accumulates. Recreational activities are limited in the nature reserve because the area is not accessible beyond a footpath that has recently been built. The lush flora in the freshwater tidal area offers the possibility of nature watching. The water bodies in the nature reserve are closed to boat traffic.

Figure 13 shows the matrix applied to the nature reserve. Economy, energy use and cultural heritage play only a subordinate role to the environmental categories of benefits. Overall, society benefits from leisure and health enhancement opportunities provided by the reserve. The protection of air, water and the planet is the global aim of having such nature protection areas, so there are wider boundary benefits than simply the local. In the Heuckenlock reserve, habitat is improved, the nutrient cycle supported and photosynthesis increased.

Society also benefits from the Heuckenlock area due to tourism and opportunities for education. An information centee provides the interested public with information about the nature protection area. Furthermore, school classes can visit to learn about the environment. The information centre is supported by the local community, which shows a high acceptability of the area in the public.

The sustainability narrative in Volume 1 describes how designation as a nature reserve and the determinations of the EU Habitats Directive require sustainable measures with three main goals: to preserve the natural function of the area, to carry out interventions if necessary (such as the promotion of settlements of endangered species) and to remove and prevent disturbing influences.

Sustainability in nature preservation means that measures have to be continuously implemented and supported. The cooperation between partners is, therefore, based on long-term contracts. The legal status of the nature reserve does not allow building and forest use; the water bodies in the area are closed to boat traffic, so the Heuckenlock is sustainably protected from interference of this kind. This is a key factor in achieving the main goal of the nature reserve: keeping the natural dynamics of the area functioning. Small interventions such as cutting and planting and larger interventions such as lowering embankments also support this aim.

## 6.5 SOLAR CITY, A SUSTAINABLE CITY DEVELOPMENT, HEERHUGOWAARD, THE NETHERLANDS

This is a 118 ha new urban area southwest of the municipality of Heerhugowaard with some 1,400 houses. Solar City is the world's largest carbon-neutral community. The energy efficient houses use solar and wind power. Plans to manage flood risk, water quality and the aquatic ecology in the area led to a water system with hardly any water supply or discharge of excess rainwater and a naturally purified water system in the main park. More than 30% of the project area consists of surface water, with a lot of variability in the water level. The permitted level fluctuation of 0.7m enables the water system to be more or less self-sufficient. Only in very dry periods is a little water supply needed. And only in very wet periods will water be discharged. Initially this flexibility in water level seemed to be impossible because of existing buildings. Eventually it was decided to raise small dikes around the historical farms in the surrounding areas to protect them from high water levels.

The ambient water quality is sustained using the natural purifying water system in the park where the water is circulated through a wetland area. However, the water quality required for swimming is rarely met, especially when the weather conditions are best. Figure 14 shows the application of the matrix to this case example.

The matrix illustrates that the main benefits are the improvements in water quality and groundwater recharge, although there are benefits in most categories. Omissions relate to enhancements of human capacity, heritage and spiritual values (although evidence from the Mayesbrook park development in the UK34 suggests that such developments can add substantially to this). Other non-rated potential benefits that might be expected to be relevant are low risk of failure, pest regulation, food, crops and other provisioning services, increases in photosynthesis and reduction in the need for grey infrastructure.

The sustainability overview in Volume 1 describes how because the Netherlands lies below sea level, all the excess rainwater needs to be pumped out to the sea. This occurs mainly during the winter. In summertime fresh water from the rivers supplies the regional water systems. The flexible water system (allowed to rise and fall) in Solar City leads to less fuel consumption in the pumping stations. This also allows more local water to be available in the area. This is beneficial from an ecological point of view, and thanks to the natural purifying water system in the park the water quality is much higher than could be expected with a traditional open water system. The photovoltaic systems together with the power of the three on-site windmills supply enough energy for Solar City and its residents to be fully carbon-neutral.

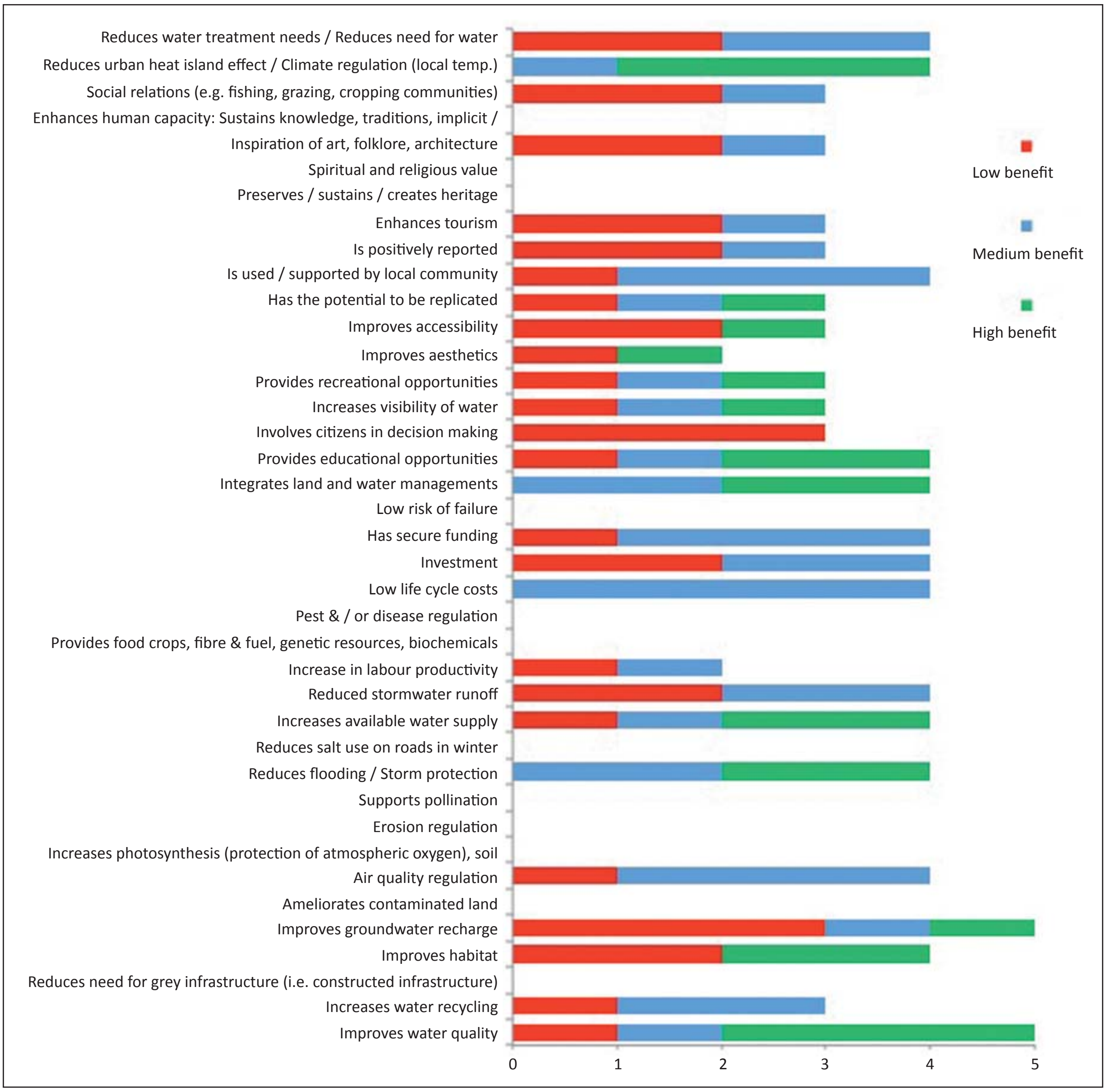



**FIGURE 14. MATRIX APPLICATION TO SOLAR CITY, HEERHUGOWAARD**

## 6.6 BEACH RESORT EGMOND AAN ZEE IN THE NORTH-WESTERN NETHERLANDS

The popular beach resort of Egmond aan Zee in the north-western part of the Netherlands experienced two extreme stormwater events in August 2006. These led to flooding of the area. The stormwater flowed from the higher parts to the lower centre and flooded shops, with damage to property and widespread impacts. The flooding and possible health risks are expected to potentially occur more often due to climate change and therefore had to be prevented. A combination of measures was selected based on SuDs systems, with road speed bumps in selected areas implemented to store and infiltrate stormwater at source. During the construction of these "simple" solutions, longer term plans were made based on spatial planning and the community. Two large infiltration basins were designed for storing stormwater in the lower-lying areas and to prevent flooding. The basins were optimised in volume by using innovative technical building solutions,

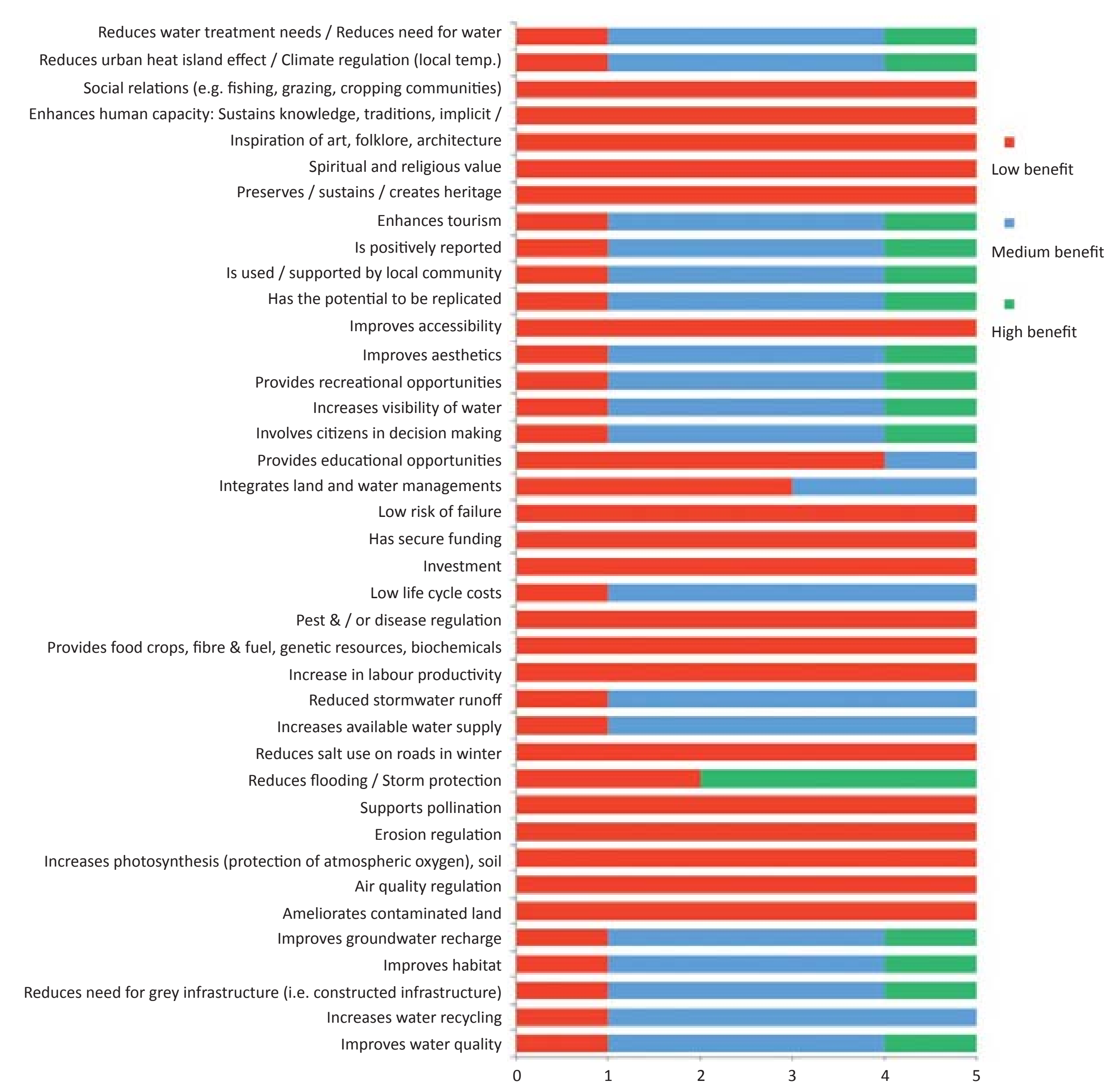



**FIGURE 15. MATRIX APPLIED TO FLOOD RELIEF IN EGMOND AAN ZEE RESORT**

constructing the walls above ground and lowering them during construction. This led to less required space for building, optimised the storage volume and minimised the obstruction for local residents.

Figure 15 shows the matrix applied to the retrofit stormwater management problem. There are apparent benefits accruing in each category, with the "reduces flooding" criterion scoring the highest in benefits. After the flooding in 2006 the need to reduce flooding was the driver to implement measures in the short term. Quick wins were implemented as "sleeping policemen" and budget was allocated for long term measures (basins etc.).

Volume 1 outlines the sustainability overview of the solutions considered in Egmond aan Zee, which were intended to be sustainable, but raised a lot of questions in the workgroups involved in the scheme. Discussions about the sustainability of the different solutions were clearly dependent upon the different interest and ambitions of the various stakeholders. The sustainability assessment of the project used 3 categories – planet, people and profit – to rate the scheme based on expert judgement. They were visualised in the discourse using a spider web figure.

## 6.7 ASSESSMENT OF BENEFITS AT LEVELS 2 AND 3

Some stakeholders considered the potential at Level 2 for a detailed analysis at Level 3 for their schemes. However, of these, only Bryggen indicated whether or not direct or indirect quantification of the benefits was likely to be feasible. See Table 7), where the criteria amenable to direct and/or indirect quantification are shown.

| Benefit | Direct quantitative analysis possible | Indirect quantitative analysis possible |
|---|---|---|
| Improves water quality | Y | Y |
| Increases water recycling | Y | Y |
| Reduces need for grey infrastructure | Y | Y |
| Improves habitat | N | Y |
| Improves groundwater recharge | Y | Y |
| Reduces flooding/storm protection | Y | Y |
| Reduced stormwater runoff | Y | Y |
| Increase in labour productivity | N | Y |
| Low life cycle costs | N | Y |
| Investment | Y | N |
| Has secure funding | Y | |
| Low risk of failure | N | Y |
| Integrates land and water management | Y | Y |
| Provides educational opportunities | Y | Y |
| Involves citizens in decision-making | N | Y |
| Increases visibility of waters | N | Y |
| Provides recreational opportunities | Y | Y |
| Improves aesthetics | Y | Y |
| Improves accessibility | N | Y |
| Has the potential to be replicated | N | Y |
| Is used/supported by local community | N | Y |
| Is positively reported | Y | N |
| Enhances tourism | Y | N |
| Preserves/sustains/creates heritage | Y | Y |
| Enhances human capacity: sustains knowledge, traditions, implicit/tacit knowledge | N | Y |
| Reduces water treatment needs/Reduces need for water purification & waste treatment | Y | N |

**Table 7. BRYGGEN – LEVEL 2 ASSESSMENT**

None of the cases attempted to move to a Level 3 analysis, although supporting information as to which of the criteria may be financially assessed is given in Annex 2. Note that very few are so far amenable to such analysis, and further R&D is required to develop the tools for this. The tools described in Sections 3 and 4 of this report can be used for certain applications, although no extant tool includes all of the criteria considered important in SKINT.

## 6.8 SUMMARY AND LESSONS LEARNT FROM APPLICATION OF MATRIX TO BENEFITS EVALUATION

The SKINT case studies outlined above cover a wide range of applications in both urban and rural settings. Whilst the matrix was developed with all of the partners in the project endorsing and proposing criteria and, uniquely, including heritage criteria together with ecosystems services, water, land use planning and environmental criteria, there are clear differences in interpretation as to what the criteria mean and how they should be considered in the evaluation process. This is evident in certain anomalies and apparent contradictions in assigning, for example, little value to the criteria benefit of flood risk alleviation in Egmond aan Zee, where this was in fact the objective of the scheme. Other anomalies are also apparent, illustrating that the matrix cannot be used as a stand-alone tool to inform stakeholders as to the potential value of the benefits of an option. Clearly expert assistance is required in application. The assessments were carried out at an early stage in the definition of the criteria and many definitions were still under development, necessitating expert judgement as to their precise scope and meaning.

Nevertheless, the matrix has proven useful in ensuring that each potential benefit is considered during option selection. There is a need to positively discard or assign a nil value to any criteria not deemed to bring value to a scheme, as each criterion needs to be considered in the matrix process.

# 7. Summary and Lessons Learnt from "Selling Sustainability in SKINT"

As stated at the beginning of this report, ideas about sustainability have remained very much static for a number of years, despite a plethora of tools to "assess sustainability". Most applications use some form or set of criteria to assess what is a good or not such a good idea. Of course, policy-makers, decision takers, politicians and everyone else wish to become sustainable and to receive services that are sustainable. The framing and visions surrounding the sustainability discourse are perhaps the most useful aspects of the concept, as they allow partnerships, stakeholders and those participating in decision processes to set their values and points of view in a "vision" that is both shared and separate. The separate vision is the individuals' personal understandings of sustainability, whereas the shared vision can be reached via a list of criteria such as the ones presented here that can be used to establish the benefits of a proposal in common and shared terms.

Flawed as such a process is, it does ensure that all pertinent potential values are included in the discourse surrounding the "best" option selection, whether or not that option is truly "sustainable" or not. The way in which the matrix presented here has been variously interpreted and used to retrospectively analyse the case studies demonstrates that even a collectively agreed-upon list of criteria can be understood in different ways by different users in different contexts.

At the present time it would seem that the idea of presenting the benefits of options to decision-makers, ideally monetised, couched in "sustainability" language, offers the best possibility to get options adopted that are as sustainable as possible. Important in this are the recently emerging ideas about multifunctionality, multivalue and getting more from less in investments in adapting to climate change.

# Annex 1. Benefits Assessment Matrix

| Category | Benefit | Level 1: Overview Assessment of Benefits to: | | | | | | | Level 2: Quantitative Analysis | | Level 3: Financial Valuation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Environment (e.g. EU biodiversity strategy) | Economy | Society | Energy use | Cultural heritage | EU Directive fulfilment (overall) | Regulations/ Directive necessary for local planning? | Direct quantitative analysis possible[1] | Indirect quantitative analysis possible[2] | Financial valuation tool available[3] |
| Protection of air/water/planet | Improves water quality[C] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Increases water recycling[ES (provisioning)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Reduces need for grey infrastructure[C] (i.e. constructed infrastructure rather than green/renewable) | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Improves habitat[C,ES (SUPPORTING)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Improves groundwater recharge[C] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Ameliorates contaminated land[S] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Air quality regulation[ES (REGULATORY)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Increases photosynthesis (production of atmospheric oxygen), soil formation, nutrient cycling and/or primary production[ES (SUPPORTING)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Erosion regulation[ES (REGULATORY)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Supports pollination[ES (REGULATORY)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| Flexibility and Adaptability to climate change | Reduces flooding[C]/storm protection[ES (REGULATORY)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Reduces salt use on roads in winter[c] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Increases available water supply[C, ES (PROVISIONING)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Reduced storm water runoff[C, ES (REGULATORY)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |

The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region
European Union The European Regional Development Fund

| Category | Benefit | Level 1: Overview Assessment of Benefits to: | | | | | | | Level 2: Quantitative Analysis | | Level 3: Financial Valuation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Environment (e.g. EU biodiversity strategy) | Economy | Society | Energy use | Cultural heritage | EU Directive fulfilment (overall) | Regulations/ Directive necessary for local planning? | Direct quantitative analysis possible[1] | Indirect quantitative analysis possible[2] | Financial valuation tool available[3] |
| Contribution to local/global economy | Increase in labour productivity[G] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Provides food crops, fibre & fuel, genetic resources, biochemicals, natural medicines, pharmaceuticals, and/or ornamental resources (shells, flowers etc.)[ES (PROVISIONING)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Pest and/or disease regulation[ES] (REGULATORY) | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| Life cycle costs | Low life cycle costs | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| Affordability | Investment[G] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Has secure funding | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| Risks | Low risk of failure | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| Public/professional engagement | Integrates land and water management[S] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Provides educational opportunities[C] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Involves citizens in decision making | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| Amenity provision | Increases visibility of water[S] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Provides recreational opportunities[C, ES (CULTURAL SERVICES)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Improves aestheticsc, [ES (CULTURAL SERVICES)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Improves accessibility[S] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |

| Category | Benefit | Level 1: Overview Assessment of Benefits to: | | | | | | | Level 2: Quantitative Analysis | | Level 3: Financial Valuation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Environment (e.g. EU biodiversity strategy) | Economy | Society | Energy use | Cultural heritage | EU Directive fulfilment (overall) | Regulations/ Directive necessary for local planning? | Direct quantitative analysis possible[1] | Indirect quantitative analysis possible[2] | Financial valuation tool available[3] |
| Acceptability | Has the potential to be replicated[S] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Is used/supported by local community | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | | |
| Media influ-ence[S] | Is positively reported[S] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| Attention to cultural heritage | Enhances tourisms,[ES] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Preserves/sustains/creates heritage | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Spiritual and religious value [ES (CULTURAL)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Inspiration of art, folklore, architecture[ES (CULTURAL)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Enhances human capacity: Sustains knowledge, traditions, implicit/ tacit knowledge[S, WP4] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Social relations (e.g. fishing, grazing, cropping communities)[ES (CULTURAL)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| Energy use | Reduces urban heat island effect[C]/ climate regulation (local temp, GHG sequestration etc.)[ES (REGULATORY)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |
| | Reduces water treatment needs[C]/ Reduces need for water purification & waste treatment[ES (REGULATORY)] | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | H/M/L/N | WFD/FD/ OTHER | WFD/FD/ OTHER | Y/N | Y/N | Y/N |

Key:
C = Center for Neighborhood Technology (CNT)
S = SKINT partner addition
G = Green Infrastructure North West (GINW)
ES = Ecosystem Services
WP4 SKINT addition

H/M/L/N = High, Medium, Low or No contribution

[1]Physical, chemical, biological benefits and impacts (e.g. via EIA/SEA)
[2]Including social, policy, strategy (e.g. green infrastructure strategies, planning processes)
[3]Mainly financial benefits and costs but may include willingness to pay (unless included in[2])

# Annex 2. Evaluation and Details of the Benefit Criteria and their Use

## USE OF THE MATRIX

The application of the matrix in SKINT is for the comparison of options intended to deliver the same outcomes, i.e. a baseline – "do nothing" needs to be used in every case to be compared with e.g. implementing a surface water management scheme using SuDS compared with a scheme using pipes. The matrix is not intended for the comparative evaluation of schemes, such as whether to tackle flood risk in one location or to tackle a water pollution problem elsewhere.

Not all of the benefit criteria will be individually relevant to each option and care needs to be taken when considering whether or not certain benefits should be weighted more heavily than others; this will be case-specific.

Setting boundaries for the use of the matrix requires careful definition of:

- Space boundary – local, neighbourhood, city, catchment, national, Europe, world;
- Time boundary – needs to consider the lifetime of the measures proposed as well as how external factors might change, such as climate change;
- Benefits boundary – at the outset of the study the boundaries presumed (usually set by policy-makers) need to be reviewed and challenged as necessary to ensure that all potential benefits are included – benefits to society as a whole rather than to a specific "client";
- Criteria boundary – in evaluation it is almost impossible to avoid overlaps and double counting of benefits as e.g. reductions in flows by using source control GIs benefits flooding, water quality and many other criteria, some of which overlap – less flooding leads to less associated water pollution when the floods drain down. It is not clear yet whether or not such double-counting problems are significant or if they balance out when comparing one option with another.

There are some boundaries that can be set for the overall analysis and some that will need to be set for each specific criterion under consideration.

## INDIVIDUAL BENEFIT CRITERIA

These are considered below within the benefit categories and using the information supplied by CNT, GINW, ES or as agreed by SKINT beneficiaries. No attempt has been made to specify precise monetary values, as these will depend upon context, country and other factors.

| Protection of air/water/planet | | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Improves water quality**<br>This can be defined as related to receiving water quality and hence to reductions in impacts (CNT) or as potentially helpful for rainwater harvesting where this is utilised. | "Using green infrastructure for stormwater management can improve the health of local waterways by reducing erosion and sedimentation and reducing the pollutant concentrations in rivers, lakes and streams. The impacts of green infrastructure on water quality, while well documented, are too place-specific to provide general guidelines for measurement and valuation. The water quality improvements associated with green infrastructure, furthermore, are not of sufficient magnitude to be meaningful at the site scale. This benefit, therefore, is best evaluated in the context of watershed-scale green infrastructure implementation." This criterion needs to be set at least at the catchment scale within which the water quality is assessed. Benefits can accrue across generations and timescales. | The CNT definition for this falls under reductions in storm water runoff (Figure 5) and each of the five GI SuDS included in the tool is claimed to assist with this.<br>Studies in the USA have estimated implicit marginal prices for a one meter change in water clarity (turbidity reduction) ranging from $1,100 to $12,938 per waterfront property. Elsewhere in the USA estimated home price impacts of water quality changes not merely for waterfront properties but for the entire watershed found marginal implicit prices for changes of one milligram per litre in TSS concentrations of $1,086 and in dissolved inorganic nitrogen concentration of $17,642 for each home in the watershed.<br>In addition to direct water quality marginal values, CNT also provide estimates of the value of not having to treat runoff at wastewater plants – for example a 5,000 ft² green roof contributes to an annual electricity savings from reduced water treatment needs of 110.77 kWh. This can be costed in terms of a marginal benefit value. |
| **Increases water recycling**<br>This is a benefit when considered for ES as it reduces burdens on the natural environment and need to abstract. It also benefits water suppliers as it reduces demand. | According to UKNEA,[74] if a process is long term and indirect it falls under ES supporting services. However, if it is a short term and direct process it will fall under ES regulating services and subcategory water quality. However, the precise category is not necessarily significant for the application here. Much of this will relate to locally beneficial harvesting in European applications. | Estimation of the value of increased water recycling needs to be linked to the benefits of both maintaining environmental flows in natural water bodies (data should be available for agricultural irrigation impacts avoided) and also in avoided mains water supply – i.e. the cost per unit of supplied water, usually potable. There are other monetisable benefits under the social and cultural categories and double counting needs to be avoided.<br>This is not considered by either CNT or GINW. |
| **Reduces need for grey infrastructure**<br>This relates to constructed infrastructure rather than green/renewable in the CNT definition. | Grey infrastructure tends to be at a local or neighbourhood scale, although linear systems such as pipelines may be regional. Most grey infrastructure has a 30 year lifetime before major renovation. Green infrastructure will have a shorter lifetime on average. | CNT states that the value of reducing grey infrastructure derives from the benefits transfer method of avoided costs resulting from the use of green infrastructure.<br>One US city estimates that it costs the city $2.71/ ft² in infrastructure costs to manage the stormwater generated from impervious areas using:<br>*total expenditure for grey approach ($) * % retained = avoided cost savings ($)*<br>For a 5,000 ft² conventional roof, capital expenditure is $13,550.<br>However, for a green roof, which in this particular study has been shown to retain 56%, there is an avoided cost saving of $7,588.<br>The SEA streets in Seattle provide cost savings for the city of 15–25%, or $100,000–235,000 per block, as compared with conventional stormwater control designs. |

[74] *http://uknea.unep-wcmc.org/* ,accessed 10-08-12

| | | |
|---|---|---|
| **Improves habitat** | There are other monetisable benefits under the social and cultural categories and double counting needs to be avoided. This criterion needs to be set at least at the catchment scale and even beyond. Benefits can accrue across generations and timescales. | CNT states that the value of habitat improvements are valued either through Contingent Valuation methods (e.g. conservation of an endangered species) or via the market process of goods that are either directly produced from the habitat in question, or elsewhere provided the habitat in question provides breeding/nursery grounds. CNT does not provide a framework for the assessment of habitat improvement benefit.<br><br>GINW show that in the UK, improvement of habitat that has an international, national or local habitat/biodiversity designation (e.g. SSSI) often result in higher valuations. For, example a Willingness to Pay (WtP) of £0.41-£1.14 per household per year was given for preserving a SSSI, compared to £0.33-£0.90 per household per year to increase an area of commercial woodland by 12,000 ha. The GINW tool uses an application of benefit values transfer from other studies within the literature in order to value habitat improvement. It is recognised that there is no widespread support for the use of WtP to value habitat/biodiversity. There is also little evidence in the literature of urban biodiversity values. |
| **Improves groundwater recharge**[C] | The benefit depends on the spatial and time scale and management level. Local values may be small, but accumulated GI measures over larger spatial scales affects other benefits, such as amelioration of contaminated land, soil erosion/ stability, preservation of cultural heritage and reduction of the need for grey infrastructure (avoided costs). Double counting thus needs to be avoided. | Aquifer levels are a function of the relationship between discharge (abstraction, evaporation and interaction with surface waters) and recharge. As GI affects groundwater recharge in highly site-specific ways, neither the CNT nor GINW approaches define specific guidelines for the quantification and valuation of groundwater recharge benefits of GI. However, the importance is recognised. |
| **Ameliorates contaminated land**[S] | This is likely to be localised in scale although impacts and benefits to human health may be more widespread.[75] Cleaning up contaminated land is also a benefit across generations and can also support ecosystems. | Contaminated land can arise from a number of sources in both urban and rural areas. The presence of contaminated land may have an effect on the use of the land, as well as creating a source of pollution.<br>None of the approaches (CNT, TEEB or GINW) define specific guidelines for the quantification of this topic. |
| **Air quality regulation**[ES (REGULATORY)] | This is potentially a trans-national benefit. Examples include greenhouse gas emission controls mitigating climate change, human health value of restricting pollution etc. | From TEEB: *"Trees and green space lower the temperature in cities whilst forests influence rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere."*<br>The urban park forest in Cascine Park, Italy,was shown to have retained its pollutant removal capability of about 72.4 kg per hectare per year (reducing by only 3.4 kg/ha to 69.0 kg/ha after 19 years, despite some losses due to cutting and extreme climate events). Harmful pollutants removed included $O_3$, CO, $SO_2$, $NO_2$, and particulate pollutants as well as $CO_2$. |

[75] In the UK the baseline approach is given in the CLEA handbook:
*http://www.environment-agency.gov.uk/static/documents/Research/clea_software_v1.05.pdf* (accessed 10-08-12)

| | | |
|---|---|---|
| | | TEEB advocates the use of the hedonic valuation methodology – the amount of money that would be paid for higher air quality. |
| **Increases photosynthesis (production of atmospheric oxygen), soil formation, nutrient cycling and/or primary production**ES (REGULATORY and SUPPORTING) | Potentially as above | TEEB: *"Soil fertility is essential for plant growth and agriculture and well-functioning ecosystems supply soil with nutrients required to support plant growth."*<br><br>There are no explicit definitions of guidelines for this topic within TEEB, CNT or GINW |
| **Erosion regulation and soil stability**ES (REGULATORY) | This is relevant locally and possibly regionally. | TEEB: *"Soil erosion is a key factor in the process of land degradation, desertification and hydroelectric capacity. Vegetation cover provides a vital regulating service by preventing soil erosion. Soil fertility is essential for plant growth and agriculture and well-functioning ecosystems supply soil with nutrients required to support plant growth."* This is linked to the contribution to local/ global economy, as well as habitat and water quality. Value could be linked to avoiding loss of productivity of land? GI generally improves soil stability in organic soils, avoiding soil moisture reduction and degradation of organic material. Avoided leaky piped solutions also reduce risk for mechanical instabilities. There are no explicit definitions for this topic. |
| **Supports pollination**ES (REGULATORY) | This is of global and inter-generational value in supporting biosystems. | TEEB: *"Insects and wind pollinate plants which is essential for the development of fruits, vegetables and seeds. Animal pollination is an ecosystem service mainly provided by insects but also by some birds and bats".* There are links to improved habitat which must not be double counted. Value could be linked to avoiding loss of productivity of land? |

| Flexibility and adaptability to climate change | | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Reduces flooding[C]/storm protection[ES (REGULATORY)]** | CNT states that the context of flooding is highly site specific. Spatial boundaries need to be defined, as well as considerations with regards to time scale (e.g. acceptable return period). | CNT state that as the context of flooding is highly site specific, no general instructions for the valuation of reduced flooding are given. Several methodologies are discussed within the report. Hedonics can be used to assess how flood risk is priced into the real estate market. Insurance premiums paid for flood damage can be used as a CNT state that as the context of flooding is highly site specific, no general instructions for the valuation of reduced flooding are given. Several methodologies are discussed within the report. Hedonics can be used to assess how flood risk is priced into the real estate market. Insurance premiums paid for flood damage can be used as a proxy for the value of decreased flood risk. Other studies have used CV techniques. The most robust technique uses hedonics to investigate housing price discounts associated with a floodplain location. A 2-5% Discount was found for houses within the 100 yr flood plain when compared to those outside. |
| **Reduces salt use on roads in winter[c]** | There is a risk for double counting and thus clear definition of the benefits boundary is necessary. Valuation of the benefits by calculating only avoided salting costs does not take into account the increased values by improved habitat, water quality and preservation of cultural heritage.<br>There are potential catchment scale benefits from this. | Of the 5 GI measures included within CNT, permeable pavements, depending on their structure, are claimed to reduce the requirement for salt on roads in winter, by up to as much as 75%. The National Research Council (NRC) indicates that road-salt use in the United States ranges from 8 million to 12 million tons per year with an average cost of about $30 per ton, although this cost has increased in recent years. In winter 2008, many municipalities paid over $150 per ton for road salt; projections for 2009 reported salt prices in the range of $50–$70 per ton- |
| **Increases available water supply[c, ES (PROVISIONING)]** | This should be considered at local, regional and catchment scales. | CNT uses the reduction in stormwater runoff in order to assess the valuation in terms of water treatment reduction, grey infrastructure reduction, increased water quality and reduced flooding. Therefore there is no direct assessment of water supply provision. It was estimated that in the US, outdoor irrigation accounts for almost one-third of all residential water use, totalling more than 7 billion gallons per day. Given this estimate, using rainwater for irrigation purposes can substantially reduce the amount of potable water used residentially, effectively increasing supply.<br>The total amount of water available for harvest is calculated in CNT by: annual rainfall (inches) * area of surface (SF) * 144 sq inches/SF * 0.00433 gal/cubic inch * 0.85 collection efficiency. |
| **Reduced storm water runoff[C, ES (REGULATORY)]** | Valuation of benefits includes avoided stormwater treatment costs (improves water quality) and avoided costs of additional grey infrastructure. These are specific benefits under protection air/ water/planet and there thus is a risk for double counting. This should be considered at local, regional and catchment scales. | Within the CNT approach, the first step in valuing water benefits is to determine the amount of rainfall (gallons) retained on the site. This is then used as the resource unit for all water benefits. All 5 GI types listed within the CNT guidance provide some level of stormwater runoff. The levels of runoff retained depend on site specific variables. Valuation of benefits from reduced stormwater runoff include: avoided stormwater treatment costs and avoided costs of additional grey infrastructure. |

| Contribution to local/global economy | | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Increase in labour productivity**[G] | The spatial, time and benefit boundaries are important to define, related to spin-off effects by the chosen option. If an option e.g. improves habitat or sustains The spatial, time and benefit boundaries are important to define, related to spin-off effects by the chosen option. If an option e.g. improves habitat or sustains cultural heritage, labour productivity in dependent tourist industries will increase, which again improves labour productivity in other connected industries.<br>This is likely to be very locally effective but potentially affecting entire economies.<br>The increase in jobs arising from the selection of different alternatives, e.g. grey vs. green infrastructure will be very locally dependent. In general green jobs will last over longer periods of time than grey, for which construction periods will employ many people, with a rapid decline in operation, restricted to maintenance and ultimate replacement/end of life dismantling. | Evidence for increase in labour productivity is given in GINW. Well planned and accessible GI can be expected to have an impact on labour productivity. The impacts include: physical health Evidence for increase in labour productivity is given in GINW. Well planned and accessible GI can be expected to have an impact on labour productivity. The impacts include: physical health improvements – resulting principally from increased exercise and improved air quality; mental health improvements – from the calming effects of the presence of trees and green spaces, and also from physical exercise – both are linked to health benefits; improvements at work – psychologists have noted that when workers have access to plants and green spaces they can be more patient, better at problem-solving and more productive; and a reduction in short-term absenteeism.<br>To estimate the labour productivity benefit of GI, two impacts must be considered: 1. Impact on labour productivity and 2. Increased profit as a result of reduced costs of recruitment. Both of these enhance the GVA per firm. However, there is a lack of empirical evidence for these. At present decrease in short term absenteeism that can be attributed to increased health of those who take physical exercise as a result of a walking/cycling intervention can be assessed. The WHO showed a reduction in short-term absenteeism in the US of 6-32% for those who did 30 mins exercise/5 days. In the UK this could result in approximately 0.4 days gross salary costs. This value must then be combined with average gross salary costs and the number of affected working people to give a gross salary cost. |
| **Provides food crops, fibre & fuel, genetic resources, biochemicals, natural medicines, pharmaceuticals, and/or ornamental resources** (shells, flowers etc.)[ES (PROVISIONING)] | Potentially a trans-national benefit for food and other provisioning services. Often not a direct local benefit where these services are exported out of the region they grow/are generated in. | From TEEB: *“Ecosystems provide the conditions for growing food. Food comes principally from managed agro-ecosystems, but marine and freshwater systems, forests and urban horticulture also provide food for human consumption.”*<br>*“Ecosystems provide a great diversity of materials for construction and fuel including wood, biofuels and plant oils that are directly derived from wild and cultivated plant species.”* In addition, non-timber forests such as latex, rubber and plant oils are important in trade and subsistence.<br>*“Biodiverse ecosystems provide many plants used as traditional medicines as well as providing raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources.”* |
| **Pest and/or disease regulation**[ES (REGULATORY)] | Natural ecological balances may ensure equilibrium conditions being self-regulating. Consideration needs to be at an ecosystem scale. In urban areas this may apply to blue-green corridors. | From TEEB: *“Ecosystems are important for regulating pests and vector borne diseases that attack plants, animals and people. Ecosystems regulate pests and diseases through the activities of predators and parasites.”* Placing a direct monetary value on this is not straightforward, but should not be overlooked. |

| Life cycle costs | | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Low ife cycle costs** | The costs and benefits need to be considered across the entire lifetime of the scheme. There are a number of approaches as to how to define the boundaries for this as outlined in Section 5 of this report. | Life cycle costs are defined as the sum of the present value of the investment costs, capital costs, installation costs, operation and maintenance costs and replacement and disposal costs over the lifetime of the project. Life cycle benefits represent the present of the accrued benefits over the lifetime. The life-cycle net benefits provide the Net Present Value (NPV) = PV benefits – PV costs. Thus the NPV can show that a scheme with higher initial investment costs can yield greater benefits over the lifetime of a project. |

| Affordability | | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Investment**G | This can be long term or short term and local or strategic.<br><br>Investment could also fall into provisioning or regulating services depending on the contextual definition. Green infrastructure could bring more potential industries which are provisioning services, whereas if it is a long-term management issue then it will fall under regulating services. | GINW state that for valuation purposes, GI affects private sector investment, helping to drive economic growth. At the wider scale, GI may provide a context for inward investment, enhancing an areas image. 33% of new investors in the West Midlands cited attractiveness of the region as an important factor in whether they invest. At the site scale, public realm and GI around a particular investment site can help attract and retain companies. Valuing these impacts in isolation from other factors is difficult. Perception surveys can be carried out, as well as assessing the willingness to pay for a high quality environment. Within the GINW tool, it is not currently possible to value the impact of GI on attracting investment. |
| **Has secure funding** | Important mainly for longer-term adaptive types of intervention. For many municipalities there is no assuredness of future planned long term funding for incremental change, hence an adaptive approach may not be wise.<br>Security of funding could be considered as regulating services longer-term. | Not specifically included in the GINW or CNT approaches. Funding assurance needs to be clear for the duration of the project investment period required. |

| Risks | | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Low risk of failure** | Could be considered a regulatory service as needs to be considered longer-term. Robustness may also be important into the future. Here the term is defined as working across all future scenarios and contexts. | Not included explicitly in the GINW or CNT approaches. Comparative assessment of failure risk is usually the reason why innovations are not taken up. Sticking with tried and tested options can give security in relation to performance. However, many such solutions are "locked-in" and may have been applicable in the past but are now no longer sensible as, for example, they require too much energy. So here, although there could be a low risk of failure, this criterion could indicate a lack of innovation. |

| Public/professional engagement | | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Integrates land and water management**[S] | This can be at a local level (site), regionally or at a catchment scale. It explicitly recognises the potential value in doing this. | Not explicitly considered in the GINW or CNT approaches as a criterion. However, co-management of land and water is increasingly seen to be beneficial for multi-value creation. See for example, the GRaBS project.[76] |
| **Provides educational opportunities**[C] | Options improving habitat or sustaining/improving cultural heritage provide educational opportunities. If one takes widest possible boundaries into account, the secondary educational opportunities resulting from maintaining or improving cultural or environmental services should be included in any valuation. | CNT recognises that the provision of educational opportunities is important; however, no explicit method for the quantification and valuation of public education is included in the guide. It is recognised that public education is a vital precursor to achieving widespread adoption of GI, and the realisation of many of the benefits.<br>This is likely to be qualitatively assessed. |
| **Involves citizens in decision making** | In principle all stakeholders need to be included here. The scale, scope and means for this are outlined in Section 4 of this report and in the HarmoniCOP guidance.[61] | Not included in the GINW or CNT approaches.<br>Project promoters need to decide to what degree involvement, participation or engagement is appropriate. |

| Amenity provision | | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Increases visibility of water**[S] | This is to raise the profile and potential for the community to value the presence of water in their landscape, neighbour-hood or places. Hence the scale will depend on the scope of the project. | No current valuation information for this, although it does relate to the value of properties in the vicinity of water. However, it is important to avoid potential double counting with other criteria when evaluating financial benefits (see "improves aesthetics"). |
| **Provides recreational opportunitiesc,**[ES] (CULTURAL SERVICES) | This is likely to be local. For example, despite having a concrete base and no green infrastructure, the "mirror pool" in the City of Bradford provides recreation opportunities for children during hot weather. | GI can increase recreational opportunities. CNT states that the value of added recreational opportunities may be measured by avoided costs in connection to health benefits (USA), or via an increase in recreational trips, the "user days", gained from GI. In one Philidelphia study 1 additional vegetated acre results in approximately 1340 user days/yr, or 27,650 user days over the 40-year project period. 1 user day equates to $0.71 present value for the 40 year project period which equates to a benefit of £951.40 for each additional vegetated acre, and approximately $19,631 for each vegetated acre over the 40 year project period. |
| **Improves aesthetics**[c,ES] (CULTURAL SERVICES) | This is local. It is dependent on the view and cultural background of stakeholders on what is experienced as improved or decreased aesthetic value. It is important to ensure that all potential benefits as a society as a whole are included, rather than to a specific "client". Although green infrastructure is generally seen as an increase of aesthetic value, the | Increased greenery has been shown to increase the aesthetic value of neighbourhoods. For example, Willingness to Pay studies have shown an increase in property values of 2-10% in areas with new street tree plantings. In Portland, Oregon street trees have been shown to add $8,870 to sale prices in residential properties and reduce the time on the market by 1.7 days. CNT states that it is difficult to isolate the effects of improved aesthetics and avoid double counting on |

[76] *http://www.grabs-eu.org/* accessed 10-08-12

| | | |
|---|---|---|
| | alternative of losing traditional infrastructure with historic value may lead to a net negative impact even where for example GI is being used. | benefits (e.g. air quality, water quality, energy usage and flood control) that also affect property values. CNT uses a value of 3.5% increase. Annual property value gains per tree over a 40-yr average in the Midwest US region range from \$4.50 – \$23.44 in residential yards depending on the size of tree, compared to £5.32 –£27.69 for public space, depending on the size of tree. |
| **Improves accessibility**[S] | This is a local criterion. | In general, accessibility is related to access for those disabled, disadvantaged or otherwise excluded from engagement with the environment, ecosystems or amenity. This could be valued using a willingness to pay approach. |

| | **Acceptability** | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Has the potential to be replicated**[S] | This will apply primarily at a local scale and relates to demonstration/pilot projects illustrating good practice that has the potential to be applied elsewhere. When applied to ES, it can fall into multiple categories: Provisioning, Cultural and Regulating services. If it is a local formal blue or green space or informal green/blue space, it can also be related to urban greening. | This will not have a direct monetary value. |
| **Is used/supported by local community** | Local criterion by definition but should be considered to apply over a long period of time. However, could be amended to apply to a wider community depending upon how the boundaries of assessment are set. | CNT states that one way that green infrastructure can make communities better places to live is through its effect on “community cohesion” – improving the networks of formal and informal relationships among neighborhood residents that foster a nurturing and mutually supportive human environment. There is also a link between increased vegetation and the use of outdoor spaces for social activity, theorising that urban greening can foster interactions that build social capital |

| | **Media influence** | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Is positively reported** | Mainly local in scale but may also be regional or broader in case of locations that are of national or even wider importance. Reputations can be lost almost instantly now but take a long time to build-up. Example: Bryggen as a World Heritage Site has a high media importance both locally and at large. | Media in all forms, and increasingly social media, is now vital for professional interaction, legitimacy and endorsement of interventions and the long-term sustainability of schemes, projects and quality of local areas. So far there are no monetised applications in media interaction endeavours, nor in the value of positive vs. negative reporting. |

| Attention to cultural heritage | | |
|---|---|---|
| **Benefit** | **Boundary conditions** | **Evaluation criteria** |
| **Enhances tourism**[s,ES] | Important at all spatial and temporal scales, although dependence upon scheme may be most important locally. | In 2008 global earnings from tourism summed up to US$944 billion. Cultural and eco-tourism can also educate people about the importance of biological diversity. The value of GI to increased tourism is calculated in TEEB and GINW by assessing the money spent on travel and local expenditure in order to visit a particular site. GINW also includes a tool to estimate the number of jobs supported by tourism and GVA associated with employment. Similar valuation methods are proposed by Getty Conservation Institute (GCI), 2002.[77] |
| **Preserves/sustains/ creates heritage** | The spatial and especially time boundaries are important when assessing values to heritage. | In the valuation of heritage one can distinguish between *use* and *non-use* values. Use-value refers to the direct valuation of the asset's services by those who consume those services (e.g. entry fees paid by visitors to historic sites). *Non-use* value refers to the value placed upon a range of non-rival and non-excludable public-good characteristics typically possessed by cultural heritage. Taken together, the use and non-use values make up what is referred to as the economic value of a heritage asset or of the goods and services to which it gives rise, i.e. the monetary value of these items as assessed by an economic analysis. Three methodologies for assessing values are: contingent valuation methodology (CVM, incl. WtP), travel cost assessments, and hedonic pricing (GCI, Assessing the Values of Cultural Heritage, 2002). |
| **Spiritual and religious value**[ES (CULTURAL)] | This is a long-term criterion and here is related to attachment to a specific locale. In some cases this may be national (e.g. Maori culture in New Zealand) in others it may be very local (sacred place). | TEEB: *"natural features such as specific forests, caves or mountains are considered sacred or have a religious meaning. Nature is a common element of all major religions and traditional knowledge, and associated customs are important for creating a sense of belonging."* There is no method to assess or quantify Spiritual and religious value within CNT or GINW approaches. |
| **Inspiration of art, folklore, architecture**[ES (CULTURAL)] | This is likely to be a local criterion. | TEEB: *"Language, knowledge and the natural environment have been intimately related throughout human history. Biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art, culture and increasingly for science."* There is no method to assess or quantify the inspiration of art, folklore or architecture within the CNT or GINW approaches. |
| **Enhances human capacity: sustains knowledge, traditions, implicit/tacit knowledge**[S, WP4] | Can apply to entire nations and is a longer term criterion than benefits of "provides educational opportunities", although double counting here is possible. | Many municipalities and organisations struggle to maintain implicit/tacit knowledge, although proper asset records and incident documentation in appropriate formats can reduce the loss of knowledge when staff leave or are no longer available. The economic value of this and enhancements in organisational capacity can be quantified financially by collecting appropriate date over time. GINW states that investment in green infrastructure |

[77] de la Torre M. Ed. (2002). Assessing the values of cultural heritage. Getty Conservation Institute, Los Angeles. *http://www.getty.edu/conservation/publications_resources/pdf_publications/assessing.pdf* [accessed 4-09-12]

| | | |
|---|---|---|
| **Social relations (e.g. fishing, grazing, cropping communities)** | This is also about community cohesion and strength and is likely to be local, but long-term. Cropping communities can be considered as provisioning services as this is related to urban agriculture. Fishing and grazing can be considered as cultural services. | can enhance access to natural green space and provide opportunities for various forms of formal and informal recreational activity – such as fishing. Studies have shown that the value attached to such investment by the public will vary across different forms of recreation and will be area-specific. |

**Energy use**

| Benefit | Boundary conditions | Evaluation criteria |
|---|---|---|
| **Reduces urban heat island effect**[c]**/climate regulation (local temp, GHG sequestration etc.)** ES (REGULATORY) | This is a multi-scale criterion, both spatially and temporally. | The urban heat island (UHI) effect compromises human health and comfort by causing respiratory difficulties, exhaustion, heat stroke and heat-related mortality. UHI also contributes to elevated emission levels of air pollutants and greenhouse gases through the increased energy demand (via greater air conditioning needs) that higher air temperatures cause. Additionally, UHI puts a greater demand on outdoor irrigation needs, thus increasing water demand and its associated energy uses. Green infrastructure practices within urban areas can help to mitigate UHI and improve air quality through increased vegetation, reduced ground conductivity and decreased ground level ozone formation. CNT states that *"While the benefits of mitigating the UHI are important to community health and vitality, current valuation of these benefits is not extensive enough to work through quantifying methods and equations".* |
| **Reduces water treatment needsc/reduces need for water purification & waste treatment** ES (REGULATORY) | Multi-scale possibilities.<br>Falls under supporting services if considering chemical and microbial water quality as it can render the water effectively unavailable for supporting services. | From CNT: *"For cities with combined sewer systems (CSS), stormwater runoff entering the system combines with wastewater and flows to a facility for treatment."* One approach to value the reduction in stormwater runoff for these cities is an avoided cost approach. Runoff reduction is at least as valuable as the amount that would be spent by the local stormwater utility to treat that runoff. In this case, the valuation equation is simply: runoff reduced (gal) * avoided cost per gallon ($/gal) = avoided stormwater treatment costs ($)<br>This figure can be aggregated to a larger scale to demonstrate the cumulative benefit that can be achieved in a neighbourhood/region. |

The Interreg IVB North Sea Region Programme

*Investing in the future by working together for a sustainable and competitive region*

European Union

The European Regional Development Fund