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Coordination and support actions

Development of a multi-stakeholder dialogue platform and ***Think*** *tank to promote innovation with* ***Nature*** *based solutions*

WP7: International Dialogue and Collaboration

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Analysis of the business case for the application of the nature based solutions

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Table of Contents

List of Figures

List of Tables

Acronyms

BAU	Business As Usual
BMC	Business Model Canvas
BC	Business Case
CBA	Cost Benefit Analysis
CBC	Classical Business Case
EC	European Commission
EIB	Environmental Impact Bonds
ES	Ecosystem Services
GBI	Green and Blue Infrastructure
HGBI	Hybrid Green and Blue Infrastructure
HIS	Human-Industrial Systems
IUCN	International Union for Conservation of Nature
IRR	Internal Rate of Return
NBS	Nature Based Solutions
NDCs	Nationally determined contributions
NI	Natural Infrastructure
NIS	Natural Infrastructure Solutions
NFM	Natural Flood Management
OECD	Organisation for Economic Co-operation and Development
ROI	Return on Investment
SCM	Stormwater Control Measures
SDGs	Sustainable Development Goals
SIBs	Social Impact Bonds
SPV	Special Purpose Vehicle
SUDS	Sustainable Urban Drain Systems
UNEP	United Nations Environmental Programme
WEF	World Economic Forum
WSUD	Water-Sensitive Urban Design

Executive Summary

Nature Based Solutions (NBS) are classified by the European Commission (EC) as addressing societal challenges by providing solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience.

Implementation of NBS across urban and rural landscapes requires development of an infrastructure business case, inclusive of the complexity of living and ecosystem components of system functioning and performance, while delivering the required “triple bottom line” for economic, social and environmental benefits. The “Classical Business Case” (CBC) for infrastructure financing delivers a reasoned case for initiating a project, outlining the details on costs, associated risks, as well as pros and cons, alternative options, actions to take, identification of potential barriers, and the predicted timescales over which the project will be completed. However, it may not necessarily capture all the benefits or value delivered. Above all, a good business case should define the risks of what might happen if no actions are undertaken (i.e. the BAU case).

In this approach, justification for a proposed project is based on the expected commercial benefit, which for NBS largely ignores the potential non-monetized cultural-socio-ecological co-benefits or dis-benefits that may accrue through implementation. New methods of business case development are required in order to overcome the strictly financial aspects, including the application of quantitative Cost-Benefit Analysis and CBC analytics that include non-market cultural, social and ecological benefits.

The specific business case for any infrastructure or urban project including NBS depends on the type of NBS and the required functional services to be delivered, and the financial mechanisms that are available to invest in the project. There are many existing public and private sector finance sources for infrastructure investment. The global imperative for sustainable economic development is the investment in the greening of infrastructure and urban spaces, that can be driven by introducing novel financing approaches, for example:

- Climate Finance,
- Impact Bonds,
- The Natural Environment Impact Fund,
- Green Bonds,
- Public Private Partnership and
- Blended Finance.

Developing the business case for NBS must address several challenges including a paucity of existing data on NBS performance assessment compared to traditional solutions, the need for a much greater range of disciplinary expertise and a wider mix of stakeholders in option selection, design, implementation and maintenance, and the need to consider the novel methods of financing due to perceived investment risks as determined traditionally by metrics such as the expected return on investment. We suggest going beyond the monetised values and look to include the value proposition offered by the in-tangible co-benefits that can be delivered through NBS.

The SITE4NBS and RISE4NBS methodology together illustrates a strategic process framework for a project used for identifying the key elements needed to develop an NBS business case and highlight the case specific data needs, and includes,

- **R**isk Analysis,

- **I**nvestment Options,
- **S**takeholder Collaboration, and
- **E**nvironmental and Socio-Economic benefits.

Furthermore, quantitative methods for monetary valuation of the non-market costs and benefits, e.g. of ecosystem and cultural services can be applied for Cost Benefit Accounting when determining the Net Present Value (NPV) of NBS that can be compared with other grey or traditional solutions. Examples presented in this report include Sustainable Urban Drainage Systems (SUDS), Natural Flood Management (NFM) and peatland restoration for landscape regeneration.

The presented finance mechanisms, business case development framework and CBA methods are used in tandem to identify the key elements for building project-specific business cases.

This work on NBS business case development is ongoing and will continue through the end of the ThinkNature project in November 2019. Further outcomes that will provide resources for broad stakeholder engagement in business case methodology development and application, which will be available on the ThinkNature platform include the following.

- Development of exemplar business cases for specific stakeholder case studies
- International synergies on business case development for international market potential
- Development of this report as a peer-review publication
- Engagement with the EC NBS Task Force 3 on Governance, Finance and Business Models

Chapter 1.- The Investment Opportunity and Business Case for NBS

This chapter comprises a brief literature review of nature based solutions (NBS), assessing their current status, the business case for their development, providing an overview of the investment options, financial instruments, and funding mechanisms for their implementation. The review draws on published academic literature, commercial technical reports, financial reports and communications, government publications and reports and publications from past and ongoing European Commission (EC) demonstrations and Research and Innovation projects.

1.1. Introduction

While NBS is a relatively new terminology, it can be described as an 'umbrella term' that has become a catchall phrase that captures the 'green' approach to urbanisation, agricultural production systems, water resources management, biodiversity enhancement, and others such as 'ecological engineering' and 'ecosystem-based mitigation' that underpin our sustainability ambitions. (Nature Editorial 2017). The International Union for Conservation of Nature (IUCN) define NBS as "*actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*" (Cohen-Shacham, Walters, Janzen, et al. 2016). Whereas the European Commission uses a broader application in which NBS are classified as providing solutions to societal challenges as solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience.

This broader definition of NBS promotes the adoption of more diverse natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions (European Commission 2015). NBS therefore bring together established ecosystem-based approaches, such as 'ecosystem services', 'green-blue infrastructure (GBI)', 'ecological engineering', 'ecosystem-based management' and 'natural capital' (Albert, Spangenberg, and Schröter 2017, Nature Editorial 2017, Nesshöver et al. 2017) with assessments of the social and economic benefits that combines technical, business, finance, governance, regulatory, biodiversity conservation, and social innovation (European Commission 2015, Niemela 1999, Goddard 2010, Haase et al. 2014). Furthermore, we suggest that the concept of sustainable (or renewable) naturally sourced and closed loop life-cycle approaches (Vezzoli and Manzini 2002) to man-made infrastructure could also be considered as forming part of the natural infrastructure or NBS. Adopting a natural approach to scaling-up public and private investments in low-emission and sustainable green infrastructure is critical to increase resilience within urban environments (OECD, The World Bank, and UN Environment 2018).

1.2. Background to NBS adoption

As we transition into the Anthropocene Era, humanity's impact on the planet becomes increasing global in character, we approach natural limits and planetary boundaries beyond which the planetary ecological cycles and environmental processes destabilize, leading to the significant erosion of Earth's resilience, reducing its capacity for self-repair and mitigation of human activities (Rockström et al. 2009). Given there appears to be universal agreement that economic dynamism will provide the necessary solutions to tackle the immediate and future global societal sustainability and climate resilience challenges, there is a dearth of tools and models that link economics, societal well-being, biodiversity and ecology, that provides a pathway for understanding the *'true value'* of nature based solutions (NBS) within local, national and global contexts. This dissociative process is driving the environmental and climate change crises we face today, and the problems are systemic and rooted in the core economic categories with which '*value'* is acknowledged; such as prices, profits, return on investment (ROI), internal rate of return (IRR) and monetisation (Pirgmaier 2018). These economic elements and their interrelations with socio-ecological phenomena and ecological destruction, are largely undertheorized (Pirgmaier 2018).

The case for NBS first emerged from the shift towards sustainable development defined more than 30 years ago, in the Brundtland report as a "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland 1987). More than two decades later, the Rio +20 conference coined the concept of the "green economy" (Barbier 2012). This popular concept is now perceived as a pathway to sustainability by international organizations such as, the World Business Council for Sustainable Development (WBCSD 2015), the Organisation for Economic Co-operation and Development (OECD), The World Bank and the United Nations Environment Programme (OECD, The World Bank, and UN Environment 2018), and the G20 (G20 Sustainable Finance Study Group 2018) and in conjunction with others, have advocated the need to finance green infrastructure and urban spaces to meet the SDGs, through re-naturing cities to deliver broader benefits to their citizens (Andersson et al. 2019, Browder et al. 2019, Krauze and Wagner 2019).

Moreover, the development of the green economy or the greening of the economy, is being pushed towards addressing the fiscal needs of sustainable development and mitigating the impacts of climate change, with NBS an essential element in achieving the climate mitigation targets refined in Paris in 2015; with cities, and urban ecosystems playing a leading role (Lafortezza et al. 2018, Vallecillo et al. 2018, Frantzeskaki et al. 2019). As governments focus on ways to most effectively finance the implementation of nationally determined contributions (NDCs), a wide range of public and private finance actors are preparing to take advantage of the numerous investment opportunities the NDCs afford. (Buchner et al. 2017).

However, if we continue using existing evaluation and design tools that denote the gradual shifts in costs and benefits, aggregate supply and demand, and so on, from natural systems into urbanized and agri-landscaped systems, we limit the inclusion of ecosystem services (ES) and underutilize or marginalizes their value. New approaches are therefore required, with NBS as one tool or developmental model,[1] that can be designed to address the restoration of resilience through a variety of integrative sustainable environmental, social and economic options or life-cycle circular solutions that can enhance both ecological and anthropological systems. NBS are ideally energy and resource-efficient, and resilient to change, but to be successful they must be adapted to local conditions (European Commission 2015). These solutions are underpinned by actions which are modelled on and enhanced by natural systems.

NBS therefore, provide transition pathways for the design of resilient landscapes and cities, that will enable them to deliver economic development goals with beneficial outcomes for both the environment and society, by representing a more efficient and cost-effective approach to sustainable development than neo-classical economic methods (Lafortezza et al. 2018). Through the adoption of this 'design' approach there is an expectation that societal challenges can be addressed through integrated socio-ecological-technological innovations that can deploy niche, novel or enhanced NBS, Natural (NI), Green-Blue (GBI) or Hybrid (HGBI) Infrastructure options that can deal with the adaptation, mitigation and resilience challenges offered by climate change. In this way the SDG's of the 2030 Agenda for Sustainable Development are addressed, with NBS acting as diverse natural framework for enabling non-human organisms and human communities to cope with environmental change and extremes.

[1] Examples of NBS include urban green spaces and wetlands, green walls and roofs, and permeable surfaces that help regulate temperatures, collect storm water, reduce air pollution, increase biodiversity, while also improving overall well-being.

Designing and deploying NBS therefore requires a new toolbox of methods and approaches, including, crucially, the involvement of specific actors, interest groups, and their relationships with the socio-enviro-technical poly-scape. A causal understanding is necessary to comprehend the magnitude of social, political, and economic changes required for a 'safe(r) environmental space' in the future, and even more so for devising viable strategies to deliver change (Pirgmaier and Steinberger 2019). Thus, capturing the value offered by this investment through the adoption of GBI, Hybrid NI or NBS for the greening of cities is regarded as highly desirable to deliver more sustainable cities, economies and broader co-benefits to communities. While finance remains far below estimates of what is needed,[2] there are several ongoing positive trends that may affect the outlook for scaling up climate and green finance going forward. These are focussed on providing clarity on potential investment opportunities, greening existing public finance flows - including industry-wide discussions on use of climate-related financial risk disclosures and reporting, that could provide support for the use of new and innovative blended finance vehicles (Buchner et al. 2017).

Beyond the purely structural considerations (Albert et al. 2017), there are three further proposed criteria for defining NBS to strengthen the concept's role in improving policy on well-defined societal challenges. Firstly, NBS should provide simultaneous benefits for society, the economy and nature. Secondly, NBS represent a transdisciplinary umbrella that encompasses experience from existing concepts such as 'green-blue infrastructure' in engineering, 'natural capital' and 'ecosystem services' in economics, and 'landscape functions' in environmental planning. Thirdly, NBS should be introduced gradually, to allow time for careful assessment of their application in real-life settings and further refinement, in the face of limited performance knowledge or risk management indicators (Albert et al. 2017).

Furthermore, other important elements of NBS performance that need to be considered include indicators for a) integrated environmental performance, b) human health and well-being, c) citizen involvement, and d) transferability. These have been identified as addressing both the supply-side (environmental performance - related to urban ecosystem services) and the demand-side (health and well-being, citizen's involvement, as well as transferability and monitoring), where socio-demographic and socioeconomic data will need to be included in any NBS assessment in keeping with the wider consultation process and identification of co-beneficiaries (Haase et al. 2014, Kabisch et al. 2016, Coles et al. 2018). These include building a balanced evidence base capable of assessing their efficacy, in particular within the context of trade-offs and complementarities with more technological-based alternatives (Kabisch et al. 2016, Nesshöver et al. 2017,

[2] The world Economic Forum suggested that there was a USD 2.5tr gap between what was needed and what is spent per year on sustainable development. WEF, 2019.

Panno et al. 2017, Meerow and Newell 2017). These designs should seek to avoid potential unintended consequences —for example, gentrification, methane production, or providing habitat for disease vectors (Haase et al. 2014, Baró et al. 2015, Haase 2017, Frantzeskaki et al. 2019).

Such initiatives should act as a focus to stimulate cooperation between actors from science, policy and practice (Albert, Spangenberg, and Schröter 2017). Kabisch et al. (2016), amongst others have also suggested that there are three essential requirements when assessing NBS: a) evidence on NBS peformance, resilience and risk abatement for climate change adaptation and mitigation; b) using adaptive reflexive governance in implementing NBS which is inclusive of new networks of society, community co-ordinators, and practitioners; and c) consideration of socio-environmental justice and social cohesion using integrated governance, that accounts for integrative and transdisciplinary participation of diverse actors. At the same time, there is a need to identify best practices and the processes through which these can be embedded and scaled up while balancing the potential to deliver disservices (Cohen-Shacham, Walters, Maginnis, et al. 2016, Frantzeskaki et al. 2019)

1.3. NBS, Business Models and their applications

There is an expectation that NBS will be resilient to climate-change and provide societal benefits, but to be successful they must be adapted to local conditions and communities. They could or should provide incentives and co-benefits for implementation, but these are often beyond the scope of the simple or classical business models or on-ground activities to capture. The limited availability of NBS business models for urban transformation is one of the major challenges to the widespread adoption and implementation of NBS (Keivani 2010, Eggermont et al. 2015, Kabisch et al. 2016, van Ham and Klimmek 2017). Meeting these challenges creates opportunities for NBS business model development and for defining new or restructured suitable financing mechanisms. Although the term business model is widely used, there is confusion about what business models are, and what the generally accepted approach is, in the application of the concept to NBS (Shafer, Jeff Smith, and C. Linder 2005, Aziz, Fitzsimmons, and Douglas 2008, Morris et al. 2006, Osterwalder and Pigneur 2010, Barquet et al. 2011).

NBS often comprises a mixture of product and services and may best be suited to a Product-Services System (PSS) type model, as opposed to a neo-classical product delivery system, in which both the products and services delivered are included in the modelled value. A PSS uses an evaluation strategy that shifts the business focus away from simply designing and delivering of physical elements to a business model that identifies both products and services (or in this case co-benefits of ecoservices[3]) that together deliver the required performance, utility and identifiable benefits (Vezzoli and Manzini 2002, Barquet et al. 2011). This approach can be developed into a strategy that promotes the goal of achieving an integrated functional solution to delivery, to create synergies in profit, competitiveness and environmental benefits, because of the opportunities which arise from broadening the 'constructed' system and benefits to be optimized (Vezzoli and Manzini 2002, Aurich et al. 2013, Coles et al 2018). This is achieved through appealing to a wider group of stakeholders, that can be engaged not only through the provision of the physical infrastructure required, but also the additional ecoservices functionality that can be delivered through NBS (e.g. HGBI).

In this way the eco-efficiency potential of a PSS business model or strategic approach can be optimized because of the stakeholders' convergence of interests. Using a services based business model differs clearly from the traditional model in the way in which it captures value which is no longer solely based on a tangible product, but is captured through the intangible relationship or ecoservice delivered or benefited from, between provider and consumer (or co-beneficiary). This should result in less environmental impact (e.g. degraded human health or ecosystem quality) by using a life cycle specific approach as its value proposition rather than the monetary focus of traditional business models (Goedkoop et al. 2009, Aurich et al. 2013). Furthermore, the adoption of an ecoservices focussed business model will invariably engage or create new types of stakeholder relationships and/or partnerships, new convergence of economic interests, and a concomitant systemic resources optimisation or resource use efficiencies. In this way a system, project or in this case NBS, that uses fewer resources, can have lower overall costs and the gains, such as ecoservices and co-benefits can be, in different ways, shared among the various stakeholders (Vezzoli and Manzini 2002, Coles et al 2018).

1.4. The NBS Business model

Owing to the growing cost of climate driven disaster recovery, loss of ecosystem services, and natural capital (such as soil health and air quality), there is growing interest in resilient natural infrastructure (NI) that promote risk reduction measures such as NBS and include natural ecosystems and simultaneously support conservation efforts (Eggermont et al. 2015, Narayan et al. 2017, van Ham and Klimmek 2017). For instance, examples of NBS include wetlands, forests, living shorelines improving coastal management, and healthy soils; provide clean air and water, help protect developed areas from extreme weather such as hurricanes, flooding and droughts, and provide climate mitigation by absorbing and storing greenhouse

[3] Ecoservices- is a more concise nomenclature for the representative Ecosystem Services derived from a particular NBS

gases (La Shire, Vaughan, and Stolark 2019). What we observe and highlight here, is a developing approach that captures the classical essence of a business model, but provides the service component of a PSS, linked with a whole of life cycle model for natural infrastructure – the NBS, that provides cost effective, co-beneficial non-tangible services, that deliver resilience to a broader range of stakeholders than would otherwise be delivered through non-service focussed 'grey' projects (Vezzoli and Manzini 2002, Goedkoop et al. 2009).

Thus, the NBS business model should reflect a triple bottom line of economic, social, and environmental sustainability in a manner that equitably serves the community. This will inherently generate a PSS (and associated Business Model Canvas (BMC)) for NBS that may require a case by case approach to the creation of the strategic business case that defines the NBS and the case-based specific data needs (see Figure 1). There by default, generating an identified need to build an analytical framework that will assist stakeholders (including individuals, communities, governments, financiers, investors and businesses) in developing the business case, as will be elucidated in the subsequent chapter.

The approach outlined is suggestive of a framework in which the 'product' or physical structure is assessed using PSS, but also by using an adaptive life-cycle impact assessment tool adopted from the manufacturing industry. This presents an opportunity to assess both built performance and services provided by NBS. Thus, we can look at the NBS typologies, assess their structural and service components, and assign potential financial instruments that could be utilised to fund delivery. While this would only be a first pass exercise, it could be used for framing the NBS typology in such a way as to define the key elements of a strategic framework, and thus defining the NBS business case and the implementable BMC as a methodology framework (Figure 1)[4].

Assessing the NBS elements of a project are not straightforward as there are seemingly an endless number of environmental mechanisms that can be linked to interventions, or infrastructure emplacement in the space chosen for construction, protection or co-benefits (Goedkoop et al. 2009, van Ham and Klimmek 2017). Selection of the most relevant environmental mechanisms is essential and is dependent on the scope of the project and the region or scale (both temporal and spatial) within which the interventions occur. However, it should be noted that there is unlikely to be a single 'gold standard' method that is applicable in all situations or NBS, and the specific data needs for each project within the Typologies will need to be derived (Figure 1). As such, we note that NBS can be implemented as a standalone process or integrated into infrastructure or urban spaces with other grey or hybrid solutions; and can be applied a varying scales. To

[4] See also Table 7 for more details on the BMC development.

achieve these outcomes, NBS are integral to the design of policies, implementation measures and actions that address societal challenges, while being inclusive of, and responding to, adaptive management or governance, and multi-stakeholder participation (Cohen-Shacham et al. 2019).

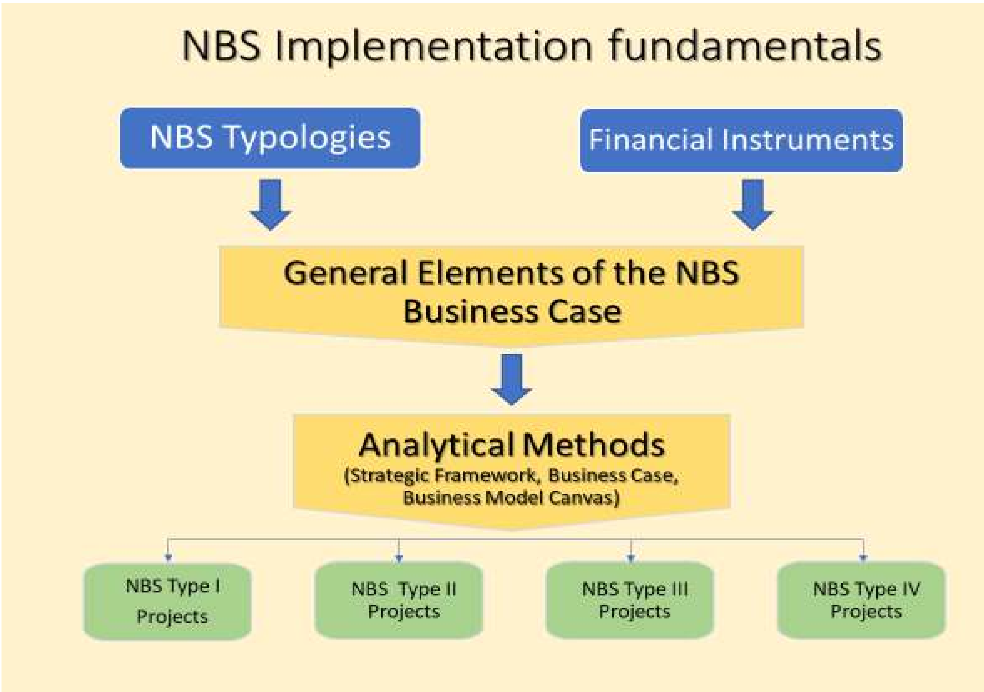


Figure 1 Stepwise process covering the fundamentals of creating, financing and implementing an NBS project. While individual typologies are shown, NBS projects can be delivered across typologies, data needs tend to be project specific to the sites in which they are delivered, although there is the potential for knowledge transfer between projects and/or sites based on expected performance criteria (i.e SUDs, NFM, Peatlands,).

1.5. NBS Typologies

One critical active pathway to alleviate poverty and support sustainable development is though the conservation and sustainable use of natural ecosystems and biodiversity. This forms the foundation and mainstay of agriculture, forests, and fisheries, as well as promoting soil conservation and water quality. NBS are one avenue that can utilised to achieve these outcomes. However, business, entrepreneurs, investors, financiers are interested in NBS, but the 'objectiveness' of their thinking is based solely on monetary returns, using traditional economics and neo-classical business models that are not structured to account for services and multifunctional benefits delivered by natural systems.

Natural systems provide a range of services, often not recognized in national economic accounts but vital to human welfare: regulating water flows, flood control, pollination, decontamination, carbon sequestration, biodiversity conservation, and nutrient and hydrological cycling (MacKinnon, Sobrevila, and Hickey 2008).

As such, addressing the scale of human environmental resource use and associated impacts, often remains an aspirational goal (Pirgmaier and Steinberger 2019). Deploying NBS thus presents both an opportunity for change, but also a barrier to implementing that change through our limited understanding of NBS performance, risk abatement, core and co-benefits value and servicing provisions.

Although the deterioration of our global environment (Rockström et al. 2009) is the focus of extensive research and prioritised in policy agendas, and even with techniques/technologies that are available to deal with climate change impacts, there are different technological and non-technological barriers that inhibit the adoption of NBS (Guerry et al. 2015, European Commission 2015). Unless NBS are utilised in a systemic manner, opportunities for local and regional stakeholders as well as business actors and experts to explore comprehensive NBS's may be missed due to these barriers (Raymond et al. 2017). The concept of ecological engineering could be considered as having the closest descriptive relevance to NBS, where a level of engineered intervention is undertaken to create the NBS, and is one of several concepts that promote the maintenance, enhancement, and restoration of biodiversity and ecosystems as a means to address multiple environmental and societal concerns simultaneously (Eggermont et al. 2015, Kabisch et al. 2016).

Some of the issues of surrounding deployment of NBS stem from the lack of clarity on what NBS are, how they are classified (Krauze and Wagner 2019, Calliari, Staccione, and Mysiak 2019), and the proposition that they need to have parallel benefits for the economy, society and nature (Albert et al 2017). By introducing NBS multifunctionality into urban, agricultural and revitalised natural-landscapes, the plethora of co-benefits produced, if not monetized but valued, are considered to be a more cost-effective and beneficial solution to address climate change impacts, as well as addressing other ecological, cultural, equity and well-being issues (Kabisch et al. 2016, Cohen-Shacham, Walters, Maginnis, et al. 2016, Kabisch et al. 2017).

A deep transformation of existing urban infrastructure systems, land and water management is needed for both climate and development, one that includes systemic conceptual and behavioural changes in the ways in which we manage and govern our societies and economies (OECD, The World Bank, and UN Environment 2018). A system of categorization of NBS has been proposed based on a) the level of engineering of biodiversity and ecosystems involved and b) the number of ecoservices and stakeholder groups that are targeted (Eggermont et al. 2015) within the context of finding new solutions to mitigate and to adapt to climate change effects whilst simultaneously protecting biodiversity and improving sustainable livelihoods (MacKinnon, Sobrevila, and Hickey 2008), with functional typologies given in Table1. Complementing the three ecosystem-based typologies is a proposed fourth typology that is based on closed loop life cycles and sustainable natural materials, and decarbonized construction techniques that can be used in conjunction with natural infrastructure.

Table 1. Functional descriptions for NBS Typologies illustrated in Figure 2. (After Vezzoli and Manzini, 2002, Eggermont et al. 2015 & Lundholm, Tran, and Gebert 2015).

Type 1 – Minimal intervention in ecosystems	The NBS consists of no or minimal intervention in ecosystems, with the objectives of maintaining or improving the delivery of a range of ES both inside and outside of these conserved ecosystems. This type of NBS is connected to, for example, the concept of biosphere reserves which incorporates core protected areas for nature conservation and buffer zones and transition areas where people live and work in a sustainable way.
Type 2 – Some interventions in ecosystems and landscapes	The NBS uses management approaches that develop sustainable and multifunctional ecosystems and landscapes (extensively or intensively managed). These types improve the delivery of selected ES compared to what would be obtained with a more conventional intervention. This type of NBS is strongly connected to concepts like natural systems agriculture, agro-ecology, and evolutionary-orientated forestry.
Type 3 – Managing ecosystems in extensive ways	The NBS manages ecosystems in very extensive ways or even creating new ecosystems (e.g., artificial ecosystems with new assemblages of organisms for green roofs and walls to mitigate city warming and clean polluted air). Type 3 is linked to concepts like green and blue infrastructures and objectives like restoration of heavily degraded or polluted areas and greening cities.
Type IV –Functionally adapted grey hybrid Infrastructure that form constructed ecosystems, or is produced from sustainable materials and closed life-cycle delivery systems	A variation of Type 3 but with decarbonized grey infrastructure, sustainable materials (i.e. forest products) and circular life-cycle construction methods alongside green-blue NBS. Further promotes NBS adoption at multiple scales, local, regional national, global. Particularly within an urban planning setting at city scales, linking a range of native natural solutions with selected infrastructure or products based on their biogeography and key functional traits. This includes an evaluation of their carbon-water-environmental footprints and closed loop life-cycles promoting a sustainable and conservative approach to engineered structures, product developments, energy use, transport, food production systems and urbanisation. These combinations focus on addressing multiple goals such as recyclability, product reuse, global emissions mitigation, bio-diversity enhancement, human well-being and better resilience to future hazards. Promotes the adoption of adequate governance and policies to properly tackle the issue at local, city, region and global scales including coherent integrative sustainability planning within cities and across borders.

In this way more sustainable urban ecosystems can be designed and implemented promoting niche green elements alongside hybrid grey-green-blue infrastructure NBS (Table 1). Type 1 and 2 would typically fall within the IUCN-NBS framework, whereas Type 2 and moreover Type 3 are often exemplified by the EC for turning natural capital into a source for green growth and sustainable development as shown in Figure 2. ***Hybrid solutions*** exist along the gradient both in space and time shown in Figure 2. For instance, at landscape scale, mixing protected and managed areas could be one system that could fulfil multi-functionality and sustainability goals. Similarly, a constructed wetland can be developed as a Type 3 but, when well established, may subsequently be preserved and surveyed as a Type 1. These scalar systems don't include Type 4 which sits outside the IUCN interpretation of nature based solutions given Type 4 is more focussed on naturally sourced basic materials for construction, manufacturing and circular life-cycles for production systems.

As is the case for engineering solutions, there is no 'one size fits all' approach given that climatic, ecological and hazard characteristics are variable and are often poorly understood. However, the construction industry use of traditional infrastructure has a long history in which they have fully developed protocols and standards. Whereas NBS are emerging techniques and activities that will most likely require the same level of investigation, documentation of lessons learned and the development of standards that focus on the key implementation challenges as they relate to the efficacy, robustness, and performance of NBS in delivering multiple benefits to cope with climate adaptation in cities (Frantzeskaki et al. 2019).

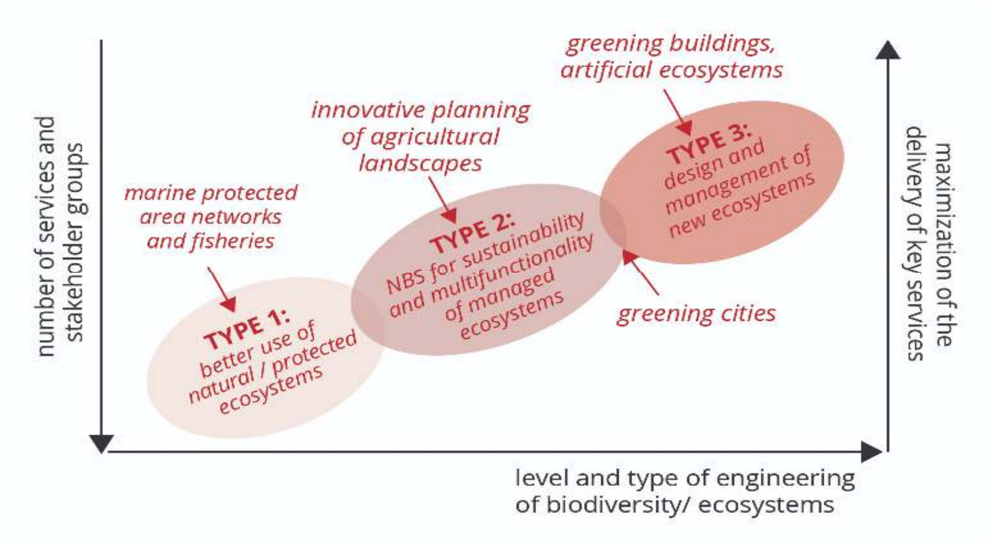


Figure 2. Schematic representation of the three main types of NBS as suggested by the IUCN. They vary in the level of engineering or management applied to biodiversity and ecosystems (x-axis), and in the number of services to be delivered, the number of stakeholder groups targeted, and the likely level of maximization of the delivery of targeted services (y-axis). Note that the y-axes could be shifted, and that the three types are considered as being complementary. Adopted from (Eggermont et al. 2015)

Therefore it is likely, that to aid financing and implementation, robust and accepted standards are required for NBS which can guide project designers, implementers, funders, evaluators and others involved in the project development. Guidance also facilitates achieving a common understanding of likely effectiveness and risk reduction outcomes of an applied solution.[5]

1.6. Financing Mechanism, Instruments and Options for NBS

For investors, nature and biodiversity are soft topics, and therefore a paradigm shift in thinking is required to be more focussed on the value proposition and value capture. Historically, there is a strong tendency to overvalue financial capital and undervalue social and human capital. The mapping and assessment of ecosystems services provides an important background for the analysis of nature-based alternatives. Recognizing that next generation infrastructure has a critical role to play in meeting the climate adaptation challenge, a growing movement is promoting nature- based solutions and creating opportunities to scale up use of green infrastructure. The *United Nations World Water Development Report 2018* highlighted how nature-based solutions (including green infrastructure) can help meet the 2030 SDGs (WWAP 2018). Similarly, the High-Level Panel on Water convened by the United Nations and World Bank concluded that green infrastructure can *"help address some of the most pressing water challenges, particularly if planned in harmony with grey infrastructure."*

Therefore, a much broader scale up of investments across all sectors of the economy is required in a timely and targeted way, delivered through a recognizable framework for assessing NBS, their performance, resilience and intangible benefits. For example, in the energy sector, including energy use in power, transportation, and buildings, the financial investment required totals over $1 trillion per year through 2050.[6] To promote and assist a transition to low-carbon agriculture, forestry, water, and waste management, requires even greater investment, while adaptation finance needs are also pressing in order to minimize the costs of climate impacts that are already locked in (Buchner et al. 2017).

This transformative agenda around climate change and green infrastructure investment needs are opening the critical political and financial pathways to create the potential diverse market opportunities for NBS, given the range of potential applications and co-benefit needs which NBS projects deliver on (OECD, The World Bank, and UN Environment 2018). The traditional publicly funded sources for conserving biodiversity, ecosystems and deploying natural solutions for anthropogenic infrastructure requirements are not sufficient to meet the expanding demand for both timely intervention and investment required. The

[5] https://www.naturebasedsolutions.org/guidance
[6] Circa 2017

costs of biodiversity degradation - and the benefits of addressing the degradation - are increasingly understood however, they are still poorly internalized by different economic sectors, including the private sector actors (Ezzine de Blas et al. 2017). Due to the pressure to find alternate solutions and a wider variety of business models, financial instruments redress the skewness in value recognition and value capture in order to explore new sources for funding that build on making a "business case" for NBS.

1.6.1. Global Scale Financial Instruments

The World Economic Forum[7] estimated that USD $5.7 trillion of natural (green) infrastructure investment may be needed by 2020 in order to realise current environmental policy objectives in sectors such as agriculture, transport and water (McNeil and Rayment 2015) and it is forecast that a further €6trn needs to be invested annually until 2030 (Jefferies 2019). There are potentially six key transformative areas that will be critical to align financial flows with low-emission, sustainable and resilient societies including planning, innovation, public budgeting, financial systems, development finance, and cities (OECD, The World Bank, and UN Environment 2018). International efforts for and by the financial sector to enhance the understanding of impacts and interdependencies on biodiversity, natural capital, disaster risk management, and natural infrastructure are developing, with investment portfolios being created as enablers for these types of NBS projects (Resilient Cities 2017, Scarlett 2017, Browder et al. 2019, Rozenberg and Fay 2019).

While pioneering examples of successful business cases for natural low carbon infrastructure and biodiversity exist, comprehensive strategies are yet to emerge to allow upscaling of financial investment in NBS (Ezzine de Blas et al. 2017, Hansen et al. 2019). Rapid socio-economic and technological developments, such as digitalisation, can open new pathways to low-emission, resilient futures and provide opportunities for enhanced innovative financing mechanisms, fiscal instruments and different mechanisms that will be needed for leveraging private funding, providing an opportunity to bridge the widening gap between financing demands and the capacity to address them (OECD, The World Bank, and UN Environment 2018).

To bridge this gap, a number of financial instruments have been proffered in recent years to provide access to the capital investment required to shift society from the current un-sustainable exploitative process to one which is more focussed on ecoservices, co-benefits and sustainability. There is now an identified need to refocus and revalue these services and benefits, in such a way as to create, support and integrate functioning ecosystems to deliver functioning NBS into urban environments for the benefit of future generations. Natural solutions are inherently multifunctional, delivering multiple benefits and services

[7] https://www.db.com/cr/en/concrete-sustainable-large-scale-projects.htm

across various sectors (Coles et al. 2018), rather than single function grey infrastructure (e.g. car park). The type of funding mechanism will vary with the scale of the project and numbers of services captured and stakeholders affected. Some examples of global level funding mechanism and activities, particularly for biodiversity and ecosystem conservation are given in Table 2, with alternative funding mechanism for NBS and green infrastructure for cities given in Tables 3 & 4.

1.6.2. Regional and City Scale Financial Instruments

NBS in cities offer benefits for the environment, for people and for the economy. But cities often find it challenging to fund their implementation and maintenance. There are various funding mechanisms that are available to provide investment for NBS projects. An excellent summary overview of financing approaches that can be used to deliver green infrastructure and nature-based solutions has been complied by Grow Green.[8] Urban-based financial instruments can be grouped into two categories using the premise that a municipality has two approaches for increasing NBS in urban areas :

1) Implement NBS projects or maintain existing NBS directly – in which the municipality pays for the intervention, either through funds it already has or by obtaining loans and revenues to finance the project.
2) Encourage other actors (e.g. residents, utilities, businesses) to implement NBS or to contribute to the maintenance of existing NBS in the public domain; in which the local authorities provide incentives to other stakeholders, or stimulate private finance by other means (Grow Green 2019).

With functioning ecosystems, delivering multifunctional ecoservices as the baseline for continued human well-being in the face of future changes, NBS associated with GBI will play an ever more important role in ensuring the resilience and sustainability of, and within, urban areas. However, their effectiveness in delivering societal benefits is largely determined by the functional system in which they are implemented (Andersson et al. 2019). NBS functionality is recognised as being transdisciplinary and therefore an improved understanding of the conditions under which different types of NBS can deliver multiple interconnected benefits and through what 'lens' these benefits are perceived by diverse groups of beneficiaries will be essential to the upscaling and implementation of NBS within cities. Once these interconnected benefits are recognised, captured and 'valued' by communities, then pathways to finance can be constructed to provide a transitional green economy across multiple scales – from communities, to regions, nations and ultimately globally.

[8] http://growgreenproject.eu/approaches-financing-nature-based-solutions-cities/

Table 2. Summary of global level funding mechanism available to finance natural solutions.

Funding Mechanism	Global Target
Bio Carbon Fund (BioCF)	A public/private initiative administered by the World Bank. , aims to. The fund supports projects that generate multiple revenue streams, combining financial returns from cost-effective emission reductions (i.e., carbon credits) with increased local incomes and other indirect benefits from sustainable land management practices. Generating multiple revenue streams while promoting biodiversity conservation and is crucial to poverty alleviation in rural communities that otherwise have limited sources of income. https://www.biocarbonfund-isfl.org/
Clean Development Mechanism (CDM),	Under the Clean Development Mechanism, emission-reduction projects in developing countries can earn certified emission reduction credits. These saleable credits can be used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. The CDM is the main source of income for the UNFCCC Adaptation Fund, which was established to finance adaptation projects and programmes in developing country Parties to the Kyoto Protocol that are particularly vulnerable to the adverse effects of climate change. T
Global Environment Facility (GEF)	The GEF is an international partnership of 183 countries, international institutions, civil society organizations and the private sector that addresses global environmental issues. GEF funds are available to developing countries and countries with economies in transition to meet the objectives of the international environmental conventions and agreements. The World Bank serves as the GEF Trustee, administering the GEF Trust Fund
REDD+	REDD+ is essentially a vehicle to encourage developing countries to reduce emissions and enhance removals of greenhouse gases through a variety of forest management options, and to provide technical and financial support for these efforts. Its focus is on reducing carbon emissions from deforestation *and forest degradation* in developing countries, and promoting the role of *conservation, sustainable management of forests, and enhancement of forest carbon stocks* in developing countries" https://redd.unfccc.int/
Critical Ecosystems Partnership Fund (CEPF),	The fund is a joint program of l'Agence Française de Développement, Conservation International, the European Union, the Global Environment Facility, the Government of Japan and the World Bank. The CEPF enables civil society to protect the world's biodiversity hotspots—biologically rich ecosystems by delivering innovative solutions that conserve these ecosystems and help communities thrive. https://www.cepf.net/
Payment for Ecosystem Services (PES)	Payments for ecosystem services (PES) are finance schemes where the beneficiaries of ESs provide a series of payments to the land managers who provide the flow of ecoservices. PES are output or Input-based payments, based on either a desired state of ES, or an action to achieve a desired state and can be a cost-effective mechanism for delivering multiple public policy objectives. (See Chap. 2)

Table 3 Table 3. Potential types of financial instruments used for implementing NBS driven by funding obtained by or through a city council, municipality or metropolitan region (particularly on public lands) (after Grow Green (Grow Green 2019, Roelich 2015).

Mechanism	Definitions
Innovative use of public budgets,	Includes pooling funding from different government departments or making use of previously untapped sources such as the public health budget.
Grant funding and donations	Includes EU funding; grants from regional and national public bodies; philanthropic contributions; and crowdfunding.
Revenue financing	• Value-capture mechanisms- such as: revenues from land sales or leases; taxes (aimed at cost-recovery); • Tax incremental financing such as: user fees; developer contributions or charges; betterment levies; voluntary contributions from beneficiaries; sale of development rights and leases; funds linked to offsetting or compensation requirements; • Non-Profit distributing; and other voluntary schemes that generate revenues.
National Climate Fund	A financial mechanism that allows countries to collect, blend, and manage all the incoming revenue streams, both international and national, related to climate change into one, centralized fund. This, in turn, competitively allocates through a variety of instruments (see below) resources to a variety of “green” projects in the country.
Social Impact Bonds	Social Impact Bonds (SIBs) are a form of outcome based contract where social investment is used to finance delivery and take the risk of outcome success. Similar to other outcome based contracts, the commissioner only pays for the intervention if successful, with investors providing upfront working capital for services. Can be deployed by Charities, Community Groups and smaller investors. Promotes Investment in preventative services, saving money over time coupled with improvements in spending effectiveness by paying directly for outcomes; Benefits include a direct link between social impact and financial return with the potential to scale up innovative interventions.[9] Challenges include complexity in commissioning especially in identifying and pricing outcomes; key barriers are annularity of budgets and procurement processes and resource constraints (time and money) are significant barriers
Municipal Bonds Agency	The UK Municipal Bonds Agency Plc helps local councils to finance their investment in projects, including infrastructure and housing, efficiently and cost effectively. Issues bonds to finance local authority projects and lowers local council’s finance cost, which means more can be invested into local economies, infrastructure and housing projects. Based on issuing municipal bonds to capital markets. https://www.ukmba.org/ Also see Kommuninvest, Swedish local government funding agency. https://kommuninvest.se/

[9] Bonds are more for community focussed outcomes around housing, support and care services. However, they could be adapted for green projects that promote community well-being outcomes.

Table 4 Table 4. Potential types of financial instruments used for implementing NBS driven by funding obtained by or through the private sector to fund public space projects (particularly on private lands) (sources: Grow Green 2019; Roelich 2015).

Mechanism	Definitions
Market based instruments	A range of instruments that use markets or price mechanisms can be used to create incentives for private parties to invest in NBS, and/or to ensure a more efficient allocation of resources Includes user charges; taxes (as incentives rather than a cost-recovery mechanism); subsidies; tax rebates; credit-trading systems; offsets for residual impacts on biodiversity/GI; and payments for ecosystem services (PES).
Developing 'Business Improvement Districts' (BID)	BIDs have been widely used in the US and Europe since the 1960s to finance and deliver improvements to commercial and industrial environments and may be applied NI improvements (McNeil and Rayment 2015). Businesses and other stakeholders enter an agreement with local government to contribute an additional levy to finance improvements in a specific area. BIDs are then free to constitute their own management body, make spending decisions, and seek additional income through various instruments (Sandford 2018).
Setting up endowments	A fund is established – e.g. through donation of property or money, developer contributions, land sales, or other finance sources – and the interest accrued from investment of the funds is used to pay for the maintenance of the green infrastructure, leaving the original endowment untouched (Drayson 2014).
Creating Public-Private Partnerships (PPPs)[10]	PPPs involve collaboration between a government agency and a private-sector company that can be used to finance, build, and operate projects, such as public transportation networks, parks, and convention centers. They can also be developed for the delivery and/or maintenance of GI, leases, concessions, or service contracts.
Revolving funds	A revolving fund is a fund replenished through repayments of the loans drawn from the fund or by a constant flow of financial contributions (UN-Habitat, 2017).
Community asset transfers	Local authorities may transfer to community organisations the management or ownership (usually via long leasehold) of public land or buildings. In the UK, the transfer can be made at less than market value, provided that it promotes economic, social or environmental well-being (Drayson, 2014).
Regulation and planning standards[11]	Although not a financing instrument as such, local authorities can apply regulatory and planning instruments to mandate GI implementation by private stakeholders, such as grey infrastructure developers and homeowners. For example, development planning regulations may require that new residential neighbourhoods incorporate a certain percentage of green space.

[10] See additional Information on PPPs in the following sections.

[11] Although this is not a financing instrument as such, this is considered one formal process through which local authorities trigger GBI implementation by private stakeholders, such as infrastructure developers and homeowners.

Crowd Source Funding	Two types based on a) lending -relevant to projects with clear income stream to repay the loan or b) equity relevant to projects with income stream to pay dividends. Brokers can help with setting up the projects using various web-based platforms and can set limits on amount of funds raised to ensure revenues remain local to the project or community. May be limited by the scale of project and capacity of community organisation to utilise the options.
Investment Funds	For example, an energy service company (**ESCO**) is a commercial or non-profit business providing a broad range of energy solutions including designs and implementation of energy savings projects, retrofitting, energy conservation, energy infrastructure outsourcing, power generation and energy supply. ESCOs deliver energy efficiency projects that are financed based on energy savings., interest in ESCO business models is growing.[12]
Sponsorship	Uses a methodology in which investment can be made using a 'bond' or low interest rate loan in which a sponsor adds the NBS on to one of its own projects and pays off the loan for both projects at the lower rate.[13] The reduced interest rate serves as an incentive for them investor to "sponsor" the NBS as part of a larger project which delivers multiple benefits through niche and mixed benefit projects.
Ecological Fiscal Transfers (EFT)	Ecological Fiscal Transfers (EFT) redistribute tax revenue among government levels according to ecological indicators such as protected areas (PA). Depending on the legal and institutional context, decentralised governments may be compensated for conservation expenditures, opportunity costs or spill-over benefits related to these ecological indicators. (Kettunen, Illes, and (eds). 2017).

1.7. Alternative Financial Instruments

Interest in green finance has increased in recent years, with two manifestations of this being the G20's Sustainable Finance Study Group, set up in 2016, and the European Commission's multi-faceted sustainable finance action plan, which is focusing on environmental matters. Although estimations of the actual financing needs for NBS, or green investments in general, vary significantly between different sources, public budgets will fall far short of the required funding. For this reason, a large amount of private capital is needed (Berensmann and Lindenberg 2016, Loiseau et al. 2016). As with any new financial instrument, it has taken some time to socialize the concept of service provisions through public goods as being a valuable non-monetised public good, as such the multifunctional services concept has struggled to bring private investors to the table. As iterated previously, an analytical framework for NBS finance development could

[12] https://www.iea.org/topics/energyefficiency/escos/
[13] https://waterfm.com/reduction-of-agricultural-nutrient-runoff-examining-new-payment-methods-to-address-source-water-pollution/

also improve the stability and efficiency of the financial markets by adequately addressing risks as well as market failures such as externalities associated with the performance of such classes of infrastructure (G20 Sustainable Finance Study Group 2018).

Owing to performance uncertainties and long-term risks that may be associated with some NBS (i.e. coastal wetland regeneration, woodlands, natural flood management (NFM)), that may not deliver immediate returns on investment, and may in fact be decades before reaching optimal performance, the level of investment and financial instruments available for that investment has been limited. One factor that acts as a barrier is that, this class of long-term financial analysis not only faces methodological obstacles, but also a lack of demand from investors (Naqvi et al. 2017). Private capital is an important source of sustainable finance to meet the demands for sustainable green finance as the global economy continues to grow, and poses increasing burdens on our resources and ecosystems (G20 Sustainable Finance Study Group 2018).

Analysts highlight the methodological obstacles, attributing the lack of forward-looking data reported by bond issuers (for example), and thus justify focussing on the short term asset risk (through innovation, divestment and acquisitions, etc.) to manage any risk in the long-term, thus creating skewness in the market place and leaving the long-term financing in the 'too difficult' basket. Here we believe there are obvious maturity mismatches between long-term green investments and the relatively short-term time horizons of savers and – even more important – investors (Berensmann and Lindenberg 2016). However, a closer look also reveals that the demand for financial analysis is heavily driven by short-term traders, and that even long-term investors actually trade their assets with relatively short horizons. Both dimensions are currently discussed or/and experimented with for climate-related risks (Naqvi et al. 2017).

The major actors driving the development of green finance include banks, institutional investors, and international financial institutions as well as central banks and financial regulators. Some of these actors implement policy and regulatory measures for different asset classes to support the greening of the financial system, such as priority-lending requirements, below-market-rate finance via interest-rate subsidies or preferential central bank refinancing opportunities (Berensmann and Lindenberg 2016). Green finance represents a positive shift in the global economy's transition to sustainability through the financing of public and private green investments and public policies that support green initiatives. Two main tasks of green finance are to internalise environmental externalities and to reduce risk perceptions in order to encourage investments that provide environmental benefits. (Berensmann and Lindenberg 2016).

Despite this encouraging momentum, the deployment of private capital for sustainable finance is still constrained due to a variety of institutional and market barriers. These constraints include: a) insufficient market awareness of the benefits of NBS investments; b) the lack of underwriting capacity; c) the lack of clarity for identifying NBS investments accurately and efficiently; and d) lack of effective NBS impact reporting (G20 Sustainable Finance Study Group 2018). Mobilising capital for green investments has also been limited due to several microeconomic challenges, including a) internalising environmental externalities; b) information asymmetry; c) inadequate analytical capacity, and; d) the lack of clarity in the definition of "green" (Berensmann and Lindenberg 2016).

Furthermore, in addition to these elements, further market analysis has identified four main market failures in the natural capital area. Firstly, the externalities and public goods usually associated with natural capital assets: these arise when the costs of using or consuming a resource are greater for society than for the individual (or company) which is using the resource, or when the assets supply services which are public in nature. Secondly, there are insufficient incentives for first movers and innovators. Thirdly, investors have imperfect information. Fourthly, the specifics of natural capital projects may discourage investors (Green Finance Taskforce 2018, Vivideconomics 2018).

In addition, financial and environmental policy approaches have often not been coordinated, with many governments not clearly signaling how and to what extent they will promote or finance the green transition. NBS cashflow profiles often feature high up-front costs and long payback periods, making them ill-suited to current financial markets, which favour short investment horizons, with many NBS having limited recoverable value which could serve as collateral for investment (Green Finance Taskforce 2018) . Thus, limiting investment in NBS projects with uncertain long-term outcomes, constraining private investment in sustainable activities that achieve positive environmental impacts, and social and economic co-benefits (e.g. job creation, growth enhancement, technological development, poverty reduction, and social inclusion). Therefore appropriate investment vehicles are required to overcome the lack of information or information asymmetry regarding the outcome of NBS investments. (G20 Sustainable Finance Study Group 2018, Green Finance Taskforce 2018). Some of these options are described in the following sections.

1.7.1. Climate Finance

In line with addressing climate change initiatives, mitigation, adaptation and resilience measures, a national climate fund can be created as source of financing for NBS providing sources of funding from public bursaries. Public sources of finance, using development finance institutions (DFIs) continue to raise, manage, and distribute the largest share of public finance and continue to make strong progress in scaling up climate finance lending in line with their internal institutional 2020 targets (Buchner et al. 2017) . These sources of funds have more recently been joined by new institutions to the landscape, such as the Green

Climate Fund, as well as other emerging market-led institutions, for example the Asian Infrastructure Investment Bank and the New Development Bank (Buchner et al. 2017).

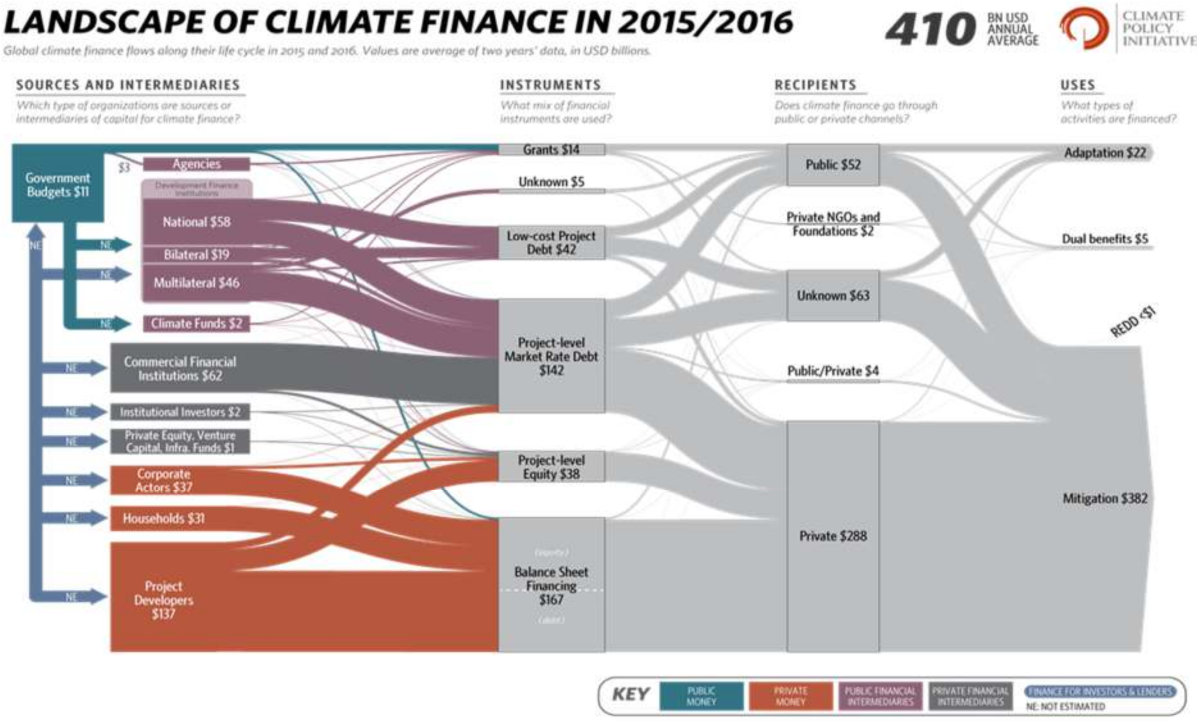


Figure 3. Representative landscape of climate finance. Source (Buchner et al. 2017)

A national climate fund is a financial mechanism that allows countries to collect, blend, and manage all the incoming revenue streams, both international and national, related to climate change into one, centralized fund. This, in turn, competitively allocates through a variety of instruments (see below) resources to a variety of "green" projects in the country. These increasingly popular national entities have been playing a crucial role as an interlocutor between the national policies for pursuing low carbon development and the international mechanisms that deliver this aid (Meirovich, Peters, and Rios 2013). The distribution of climate finance, sources, instruments, and beneficiaries is given in Figure 3.

1.7.2. Impact Bonds

Impact investment focuses on issues that are typically addressed by governments alone and offer opportunities for more efficient delivery of public services, policy-makers can play a critical role in mainstreaming this approach by providing the enabling environment needed for thriving multi-stakeholder engagement (World Economic Forum 2018). Impact investment, can be structured to create opportunities for Investors that care about environmental and social returns, rather than financial gain have the opportunity to invest in project that bring about real change or what is termed "impact investments." This can be considered as *sustainable investing* that is part of a much broader approach, incorporating environmental, social and governance (ESG) factors into investment decisions, but prioritizing financial returns, while not necessarily, intentionally creating and measuring the social or environmental impact (World Economic Forum 2018). Individuals and organizations can then invest on the basis of environmental, social and financial returns when funding projects, in this case NBS. However, appropriate policies need to be enacted by governments to ensure the smooth and efficiency delivery as impact investing cuts across a multitude of social and environmental issues and domestic and international development policy areas (World Economic Forum 2018).

Social Impact Bonds (SIBs) are not usually actual bonds, instead they are contracts between the parties involved (Gonnella 2017). The 'bonds' are a form of outcome-based contract where social investment is used to finance delivery and take the risk of outcome success. Similar to other outcome-based contracts, the commissioner only pays for the intervention if successful (Figure 4).

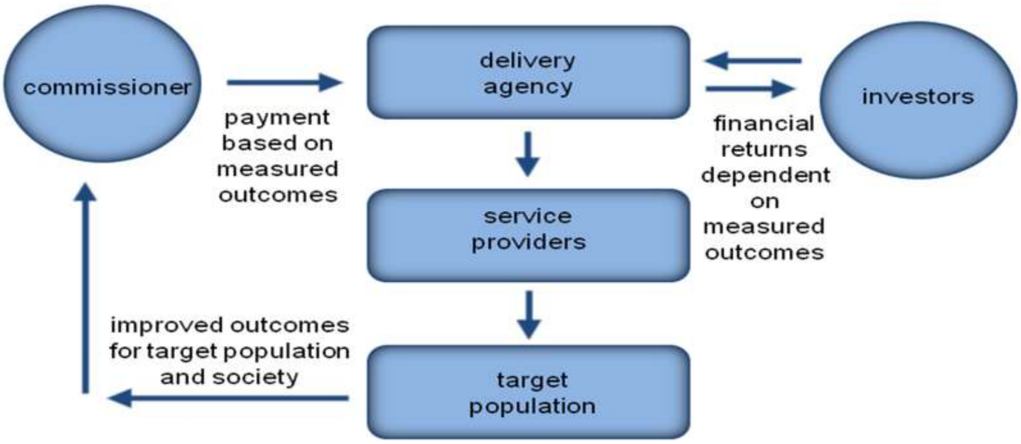


Figure 4. Basic principles of a social impact bond that could be adapted to provide or fund 'green' services through NBS.[14] *(Source Big Society Capital, 2019).*

Investors provide upfront working capital for services and are only repaid if outcomes are achieved. In many instances SIBs are delivered through a Special Purpose Vehicle (SPV), a new entity set up for the purpose (Disley et al. 2015). An SPV acts as a legally distinct entity, reducing liability to the parent company, and finances large new stand-alone projects off the corporate balance sheet (Turley and Sempl 2013). SPV's could be used to fund new innovations that enable scale evidenced alternative approaches to services delivery- for instance health benefits from green spaces (Drayson 2014, Haase 2017, Andersson et al. 2019).

[14] https://www.bigsocietycapital.com/what-we-do/current-projects/public-service-reform/outcomes-contracts-social-impact-bonds

Environmental Impact Bonds (EIBs) - Environmental Impact Bonds provide access to funding for projects that are normally difficult to finance and make it possible to obtain financing more quickly by engaging new types of investors. The risk associated with green infrastructure projects can be difficult to assess, and by financing them through an EIB, the risk is shared by both the municipalities (or local councils) and investors. Using this type of financial instrument enables the public sector (e.g. municipalities) to embrace green strategies since they are not exposed to entire risk of failure**.** In this format the EIB is similar to a SIB in that it is a contract between parties that says, '*a portion of the repayment to investors will be based on the outcomes of an intervention.'* For instance, in the case of using NFM to manage flooding it pertains to the efficacy of green infrastructure in reducing stormwater runoff. The issuing of an EIB will facilitate the redistribution of the performance risk between public and private actors (Gonnella 2017), such that it becomes a Pay for Success (PFS) transaction.[15]

In understanding the use of EIBs, there are three general principles. Firstly, the EIB acts as a tax-free bond, as it functions as a debt security issued to finance capital expenditures and backed by local government or municipality, (e.g. as in the case for DC Water)[16] with regular payments of interest and full repayment of principal at the end of the term. Secondly, it is financing environmental outcomes instead of social outcomes (like education, juvenile justice, etc.). Thirdly, unlike some SIBs that are financing an intervention through projected cost savings, an EIB can be structured to incentivise innovation by sharing risk between the payor and the private investors (Gonnella 2017).

However, for EIBs, unlike green bonds for instance, the financial return of the investment is tied directly to the success of the project. Once bonds have been issued, the issuer uses the obtained funds to pay for their planned green infrastructure solutions. Following an evaluation period, the issuer pays the investors an outcome profit when there is demonstrable proof that the green infrastructure has performed better than expected. If it underperforms, however, the investor must pay the municipality a "risk-sharing" payment. This usually means that the investor receives little or no interest.[17]

1.7.3. Natural Environment Impact Fund (NEIF)

Environmental impact projects can be divided in two categories based on whether the project: a) provides revenue streams of sufficient size and security to attract significant private sector participation; or b) modelled performance and policy conditions are pre-evaluated to the point that encourages investment

[15] https://waterfm.com/sharing-risks-rewards/
[16] https://centers.fuqua.duke.edu/case/2017/01/13/environmental-impact-bonds/
[17] https://waterfm.com/a-closer-look-at-environmental-impact-bonds/

in the near term (see Figure 5). Vivideconomics (2018) suggested six priority investment areas, in which these business models could be applied in the UK, which are:

- new woodland creation, both for recreation purposes in peri-urban areas and for timber production;
- peatland restoration;
- biodiversity and natural capital net gain;
- place-based strategic investments;
- catchment services;
- sustainable drainage systems (SUDS).

The NEIF proposed by the UK Government would create the conditions to further strengthen this business model for implementation for NBS. For instance, interventions by the NEIF may mitigate policy risk around carbon credits, aggregate projects to achieve economies of scale in finance, and address the mismatch between project return timescales and candidate investors' time horizons (Vivideconomics 2018). Evaluating NBS in this way provide a financial, spatial, and temporal framework, while also identifying potential stakeholders and co-beneficiaries.

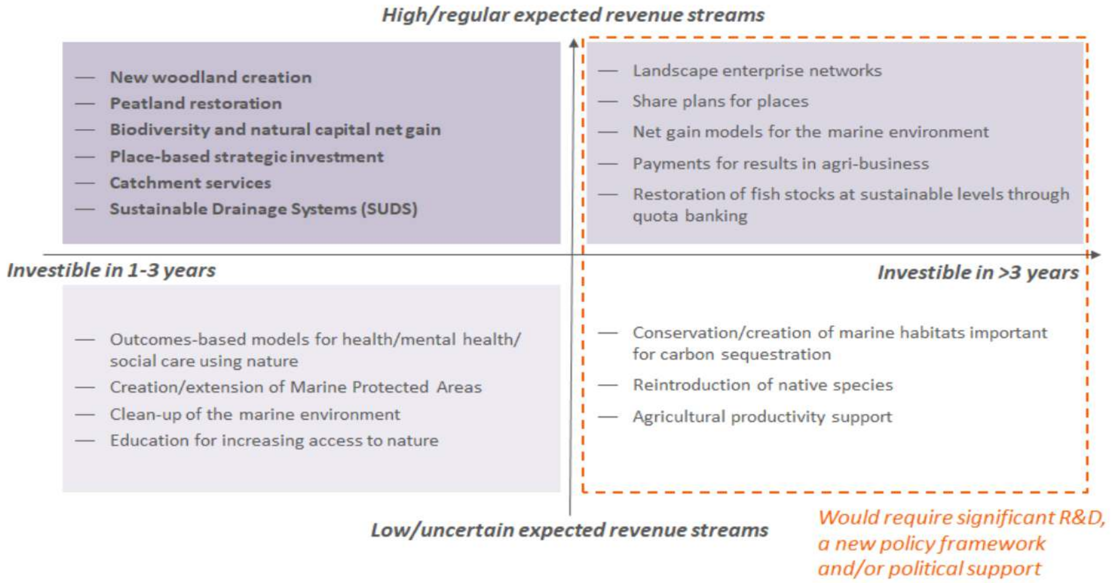


Figure 5. Potential investable environmental impact projects. Source: (Vivideconomics 2018)

1.7.4. Public-Private Partnerships

UN-Habitat, (2017) defined PPPs as *"long-term contracts between a private party and a government entity, for providing a public asset or service, with the private party exposed to significant risk and management* *responsibility*." Green infrastructure PPPs are technically, economically, politically, and contractually difficult arrangements and while PPPs are not new, with the renewed interest in using them for green investment, is through the alignment of multiple incentives. Part of this exploration means new kinds of agreements are required between governments at all levels and the private sector to deliver, green finance, and maintain a range of NI projects.

Therefore to go beyond simplistic notions of just privatization, there now exists genuine interest is in true partnerships between agencies, private firms, financiers, and communities (Sabol and Puentes 2014). So to be successful in creating financing opportunities for NBS, through NI, there needs to be a process that will offer a predetermination of its potential success, the projects performance criteria, how this will be measured and how it will reward the NBS or ecoservice providers that meet and exceed these goals (see Box 1).

Box 1. Main Actions nd Elements for developing a Public-Private Partnership (source Sabol and Puentes, 2014)

Action	Description
Create a strong legal framework at the state level	PPPs require a sound legal basis to ensure that the public sector has the authority to pursue a deal and allows the private sector to mitigate unnecessary political risk
Prioritize projects based on quantifiable public goals.	Not every infrastructure project is suitable for a PPP, so it is essential for policymakers to base their procurement decisions on economic and financial analysis that captures the social, environmental, and fiscal impacts of the deal
Pick politically smart projects.	A successful PPP requires a pragmatic understanding of what is feasible in a constantly evolving political environment
Understand what the private sector needs	Strong partnerships are based on finding the right alignment of interests, which is why it is essential to understand what makes a project appealing to private sector investors
Find the right revenue stream	PPPs are not free money; they require localities to find durable and resilient revenue sources that will pay for the investment over the long-term
Create a clear and transparent process	Routinization and standardization will create a market for PPPs that provides the public and private sector with a clear roadmap for success.
Build an empowered team.	Assembling an empowered public sector team that is capable of making and executing informed procurement decisions is an essential part of any successful PPP
Actively engage with stakeholders	PPPs are inherently complex deals that require significant public engagement to ensure that the deal is in the interest of the community and executed at the highest standards possible
Monitor and learn from the partnership	PPPs involve decades of dedicated attention that requires thoughtful monitoring, flexibility in the face of a changing world, and a willingness to learn from mistakes

Sabol and Puentes (2014), in part, attributes this growing interest to: a) tightening local government and metropolitan budgets; b) increases in project complexity associated with NBS performance criteria; c) seeking better value for money; d) the desire to leverage private sector expertise, and e) shifting public sector local and national priorities. Therefore in financing a project through PPPs, the option enables an NBS to be implemented, or to make it a possibility in the first place (Roelich 2015). There are a myriad of structures and arrangements that can facilitate this relationship, but all involve some degree of risk transfer away from government to a private firm, or consortium of firms (Turley and Sempl 2013, Hovis et al. 2017) with different PPP risk models featured in Figure 6. These risks may be associated with the investment, design, construction or operation of an asset, and can be assigned as part of the risk, benefit or control of that asset. For example, infrastructure, public building or civil engineering works, or the provision of services, such as waste or water management. While PPPs have the potential to deliver high-quality public goods and services, they are not a panacea for overextended government budgets, as private partners will inherently require compensation from the public purse (Turley and Sempl 2013).

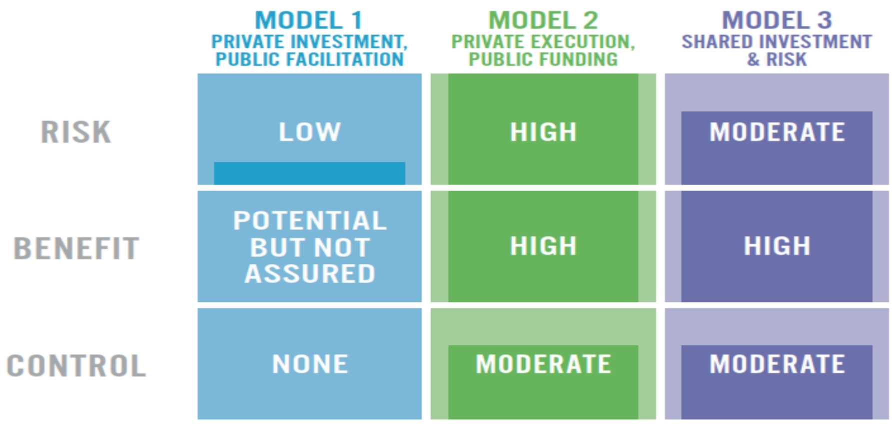


Figure 6. Trade-offs associated with Risk, Benefit, and Control in Public–Private Partnership Models (Hovis et al. 2017)

1.7.5. Green Bonds and other bond instruments

For the last ten years, the notion of a green economy has become increasingly attractive to policy makers. However, the green economy covers a lot of diverse concepts and its links with sustainability are not always clear (Loiseau et al. 2016). Urban and Business Greening investment at scale, is a nominal precondition for achieving global sustainability, though the SDGs and green finance will play a significant role in providing one pillar of greening markets, including market-oriented mechanism and financial products (World Economic Forum 2013). One of the best-known facets of green finance are green bonds. There are different types of green bonds, but the most common one is where the proceeds are earmarked for environmental projects. The green bond market can be traced back to issues from the European Investment Bank in 2007, and the World Bank in 2008, and while it was some time before there was significant growth in this market, more than $550bn (€481bn) of green bonds have been issued since 2013 (Rust 2019).

New kinds of investments are therefore required to achieve not only the sustainability goals but also promote NBS and green infrastructure investments that can manage pollution emissions, enhance urban ecosystems and deliver resilience to cities and businesses from unexpected extreme events. This is known as the *resilience dividend* (Rodin 2015), that could be delivered more effectively through NBS. The greening of municipal financial instruments, such as congestion charges, variable parking fees, toll lanes and split-rate property taxes, is an important first step toward achieving greener urban infrastructure (Merk et al. 2012). Greening public sector financing of itself, however, is unlikely to deliver sufficient stimulus to force a paradigm shift (Merk et al. 2012). Therefore, it is critical to mobilise and engage with private sector investments to bridge funding gaps, as a key partner in the process of increasing the uptake of NBS.

Going forward it will be necessary to create partnerships in which the private sector knowledge of markets, management experience, and ability to harness advanced research and development to deliver solutions will be essential and critical assets for implementing NBS in response to environmental challenges (Perrin 2018). However, this engagement will require certain preconditions to be met before investment: a) markets for green urban investment projects, b) return on these investments, and c) managed or limited risks (Merk et al. 2012).

Various financial market actors have identified green bonds as a key instrument of climate finance that can contribute to the shift towards natural infrastructure, NBS, and a sustainable urbanized economy (Berensmann and Lindenberg 2016). Green bonds[18] are here defined as bonds where the proceeds will be exclusively applied to finance or re-finance a combination of both environmental and social projects (Rust 2019). The bond market, which includes longer-term debt instruments delivered by governments, regions, municipalities, and enterprises, is mainly used to change illiquid assets into tradeable assets, backed by securities. Green bonds have several benefits for NBS and investors because they represent an additional source of financing for green investments (Berensmann and Lindenberg 2016). There are also several types of tax incentives policy makers can put in place to support green bond issuance (*see Box 2*).

In additon to green bonds there are a range of debt capital market products can provide pathways for institutional investors to finance or refinance these loans for sustainable developments or NBS. For

[18] Green bonds are fixed income securities issued to raise the necessary capital for a project.

example: sustainability-targeting bonds, covered bonds, asset-backed securities (ABS), mortgage-based securities, and collateralized loan obligations (CLOs). Other pathways to develop NBS debt capacity involve institutional investors underwriting NBS debt on their own or investing in funds that underwrite these sustainable assets and investing through digital platforms for deal origination.

Box 2. Incentives can be provided either to the investor or to the bond issuer (Green Finance Taskforce 2018)

Tax credit bonds: Bond investors receive tax credits instead of interest payments, so issuers do not have to pay interest on their green bond issuances. *Eg. US Fedreal Governments Clean Renewable Energy Bonds (CREBs) & Qualified Energy Conservation Bonds (QECBs).*
Direct subsidy bonds: Bond issuers receive cash rebates from the government to subsidze their net interest payments*. Eg. US Fedreal Governments Clean Rebewable Energy Bonds (CREBs) & Qualified Energy Conservation Bonds (QECBs).*
Tax Exempt Bonds: bond investors do not have to pay income tax on interest from the green bonds they hold (so that the issuer can obtain lower interest rate). *Eg. Municple bonds in the US market; Tax exempt bond issuance for finaincing wind turbine projects in Brazil.*
Green Revenue Stream: Based on Green taxonomies- businesses provide options for natural services within their products. The producers are required to provide rationale and evidence as to why they have a specific environmental utility. Provides consumers with a choice to go green.

1.7.6. Blended Finance

Blended finance most commonly refers to the use of concessional development capital from public and philanthropic sources to create more attractive investment opportunities for the private sector to contribute to sustainable development and greening the economy (Convergence 2018). This type of financial instrument can provide flexible funds to facilitate project development and reduce the investment risk, so as encourage capital and knowledge to flow to more risk-averse investors, helping to develop a deeper and more mature finance market. While blended finance is simply a structuring approach, most investment transactions are aligned to many alternative asset classes, such as private equity, infrastructure, and illiquid credit (Convergence 2018). The focus is not only about discrete asset classes, but about cross-cutting activities such as risk analysis. For example, The Sustainable Finance Study Group, assessed the case for collateralised loan obligations as a way to connect bank loans for sustainable energy infrastructure projects with *"deep pools of institutional investor capital"* (Rust 2019). In the case of natural infrastructure investment, greater value is created through broader stakeholder engagement through the multifunctional capacity of such projects, being more than its mere physical characteristics, and explores the environmental, social and institutional conditions under each NBS is designed, constructed and operated (WBCSD 2015).

Blended finance offers an approach that will require greater coordination between public investors, and a more direct link between public funding and private investments (Guarnaschelli, Limketkai, and Vandeputte 2018). A recent survey of investors and fund managers conducted, as a joint initiative of the World Economic Forum and the OECD, concluded that the non-financial benefits of blended finance were varied and included the ability to address market failures, extend the reach of finance, reduce risk exposure, increase the viability of innovative structures and access specialized knowledge from partners (World Economic Forum 2016). Furthermore, an evaluation of the clean energy sector indicated that blended finance is essential ingredient in to increase private investment in critical markets, particularly emerging markets (Tonkonogy et al. 2018).

In developing resilient cities and connective infrastructure, sustainable land use (SLU) in one area that could provide solutions to climate change, through the shift in land management practices, creation of green spaces, blue-infrastructure within cities, through promoting a reduction of carbon emissions via NBS. Support regions within and surrounding cities can provide opportunities to invest in SLU. To capitalise on the opportunities offered by land use land cover changes (LULC) towards SLU, there needs to be a paradigm shift in the way in which, a) private sector investors view investment opportunities in SLU and how b) public and philanthropic investors engage to catalyse private capital (Guarnaschelli, Limketkai, and Vandeputte 2018).

This shift will require the development of specific revenue generation models, financial structures and blended finance instruments that can properly capture long-term economic and in-tangible values. An integrated landscape approach combining multiple revenue models and financial structures within a region or government jurisdiction provides opportunities for creating an investment model which links production, conservation and social inclusion (Guarnaschelli, Limketkai, and Vandeputte 2018). This could involve financial structure options for value capture (e.g. real estate, debt, equity, results based finance or EIBs) and could provide revenue through various revenue models (e.g. sustaiable production, carbon & other credits, PES, ecotourism) that will realise the environmental impact at scale (Guarnaschelli, Limketkai, and Vandeputte 2018).

However it should be recognised that designing a particular blended financing intervention is largely dependent on the specific needs of a project and the circumstances and externalities that surround it (e.g. policies, regulation, community support). Given these attributes and its track record, it is inevitable that blended finance can act as a vehicle for delivering NBS on multiple levels and across industry sectors.

1.7.7. Payment for Ecosystem Services (PES)

Monetary incentives like PES, rely on price signals to change behaviour. They help 'internalise' the value of ES in land management decisions and thus to provide services that would not be delivered otherwise. Designing such incentives requires an understanding of the following variables associated with the NBS including: a) private and social benefits, b) beneficiaries of the ES (this will help identify potential financing sources); c) costs including opportunity costs and transaction costs involved in the design of an incentive scheme; d) the need to adapt to different funding sources (e.g. funding and appraisal criteria for flood defence grants differ from those for woodland grants); e) the difficulty for local communities to understand the benefits of NBS, and f) the challenges in assessing and monetising co-benefits; and g) the difficulty in assessing costs and benefits compared to traditional hard engineering. The latter comprise the costs incurred by the search for information, the bargaining, and the monitoring and enforcement of the scheme or contract.

The estimated value of the ES delivered by NBS (or equally the value of losses derived from lack of intervention) and cost-benefits information can be used to inform decision-making, including designing incentive mechanisms for investing into NBS. Such a mechanism like PES, may need to involve private landowners, providing them with an incentive to change or adopt new management practices, as it is the case for peatland restoration and NFM.

1.8. NBS Champions

To achieve the best outcomes for NBS projects there is need to create or provide a facilitator or 'champion' of the project, someone who is able to bring experience, networking and knowledge of partnerships to the table (Ezzine de Blas et al. 2017). These facilitators will provide the insights necessary to identify the beneficiaries of NBS, and help facilitate a continuous coproduction process with all stakeholders at multiple scales and across sectors (Frantzeskaki et al. 2019, Hansen et al. 2019). Whether led from the public or private sector, stakeholders with a material interest (benefit or loss) in NBS's should be mapped to understand what the business case is and who should be involved (see Figure 7).

1.9. Key findings

The challenges of global urbanisation combined with climate change will define the role of cities in the 21st Century, to create a more resilient nature based, resource efficient and sustainable future. NBS have been shown to yield multiple material benefits to the environment, society and the economy, and can be more effective than traditional alternatives during their lifecycle, however, we have shown that such projects are constricted by the lack of understanding of their economics, risk management, ecological benefits and performance metrics. Similarly, it has been noted that NBS are inherently multi-, inter-, and transdisciplinary and span different types of expert knowledge, disciplines, and ontological and epistemological approaches that must coalesce to foster interactive useful collaborative solutions. (Vivideconomics 2018).

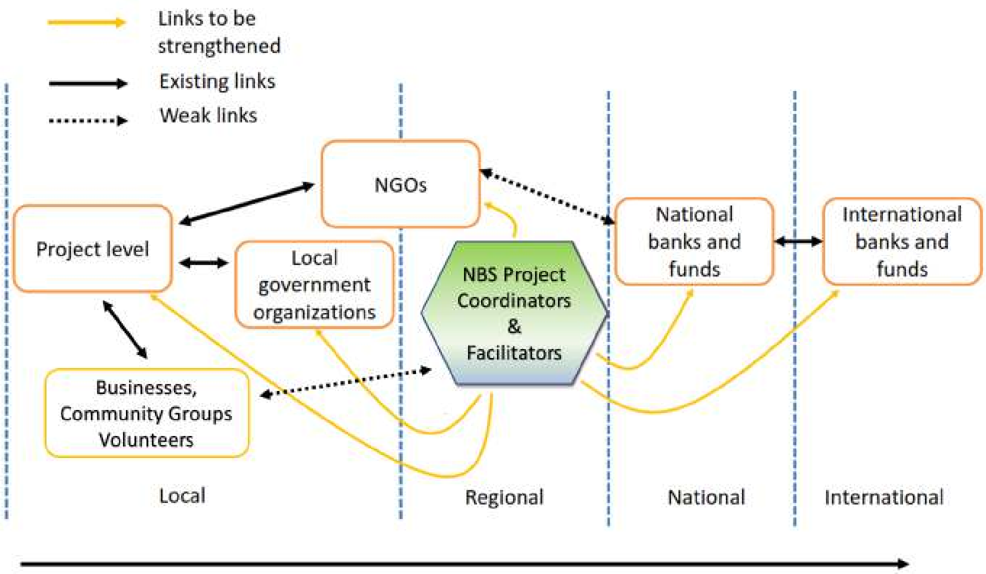


Figure 7. Using co-ordinators and facilitators to link stakeholders and investors to deliver projects at multiple scales. Adapted from (Ezzine de Blas et al. 2017)

The benefits

NBS focus on the benefits to people and the environment itself, to allow for sustainable solutions that impart resilience enabling future communities to respond more readily to environmentally driven extremes in the long-term. NBS are best delivered through multiple stakeholders, or if singularly, with the understanding that there will be multiple beneficiaries that will be affected, however indirectly, that should be accounted for in analysing the benefits delivered. By creating, promoting and implementing NBS, we as a society protect the global natural capital and retain the value inherent in ecoservices which will be fundamental to delivering sustainable development objectives. Shifts in agro-ecology, urbanisation, industry development and environmental management (both terrestrial and marine) will be required to ensure the future of the next generation. Climate change represents one of the greatest challenges to the future, and through NBS, rethinking governance structures and education, by promoting humanitarian goals and a paradigm shift in traditional economics toward resource resilience, recycling, closed loop manufacturing and inclusiveness, there is an opportunity to create the diverse capabilities we will need to meet this challenge. Cities represent the forefront in leading and meeting this challenge.

Through this review we have recognised that while NBS can deliver greater benefits, we have Identified the requirement to develop a solid evidence base on the multiple benefits, and particularly the cost-effectiveness of nature-based approaches that will engender greater support for their implementation. Understanding the relationships between practical performance, co-benefits, integrated ecoservices, and economic returns require a more informed analysis. The new generation of NBS that have inherent value with mostly public good characteristics, that are necessary to achieve sustainable development and deliver the necessary integrated services required by future urban populations, have been shown to be difficult to characterise through neo-classical business cases. Recent research has drawn upon the ES framework for assessing the biophysical or economic value of ecosystem-based approaches in cities (Baró et al. 2015), raising societal awareness of the nature based sustainability that humanity relies on, thereby promoting the translation of these recognised values into a revised nature led economic future. This notion can be transferred into urban environments thorough embracing Hybrid, Grey-Green-Blue Infrastructure (HGBI) to enhance resilience in cities, biodiversity, and human well-being.

We have noted that while NBS is often more cost-effective than traditional grey infrastructure alternatives, the barriers to implementation are more complex and are linked to change management, education, partnership working, and securing investment for an emerging and less understood sector (Eggermont et al. 2015). As such, significant barriers remain in defining a clear business case and securing financing for NBS are prerequisites to successful implementation. NBS go beyond the traditional biodiversity conservation and management principles by “re-focusing” the debate on humans and specifically integrating societal factors such as human well-being and poverty alleviation, socio-economic development, and governance principles (Perrin 2018, Eggermont et al. 2015). The Member States of the EU are in the process of mapping and assessing ecosystem services, including their economic value and in incorporating these values into EU and national accounting and reporting systems to protect, conserve and enhance the Union’s natural capital (Maes et al. 2018)

The strategic case for NBS

The literature suggests that securing investment often faces two key challenges: first, that private investment will also yield public benefits (e.g., flood protection) and, second, that return on investment is typically higher risk and longer term than for other investment opportunities. Although research has been undertaken on the types and availability of business models for NBS, there appears to be traditional financial and economic evaluations available for NBS but not specifically targeted at cross-sectorial involvement in financing from the both the private and public sectors.(Toxopeus and Polzin 2017, Frantzeskaki et al. 2019, Grow Green 2019).

Providing an accountability framework for natural systems, ecosystem services and potentially, transferability to NBS and Natural Infrastructure solutions (NIS) in the near future is essential for increased adoption. As with ecosystem services, many of the benefits of NBS are not monetized (Small, Munday, and Durance 2017), and as a result we tend to overvalue financial capital and undervalue social and human capital. Thus in failing to value natural, social and human capital, humanity has undervalued the importance of functioning ecosystems (Small, Munday, and Durance 2017), and in part, given free ride to the economy, in which the polluter doesn't pay, the developer isn't responsible, corporations don't deliver equity and governments are complicit. In this situation, the consumer or communities are unable to realise the full value of the capital and services consumed in a so called 'sustainable growth' economy. Consideration of these benefits and beneficiaries need to be embedded in a wider, coherent strategy at research and policy level. Similarly, trade-offs and unintended consequences depend on the diverse characteristics of NBS themselves, as well as the features of their design and implementation, which include additional social and economic dynamics and policies, which should enhanced their performance and promote implementation. Otherwise, NBS run the risk of misinterpretation, misapplication, and non-acceptance.

The business case

The main contribution of developing a business case is the creation of practices that help business, communities and governments capture, understand, design, analyze, and change their focus away from exploitative practices toward more inclusive models that deliver or enhance the greater benefits and encompass a wider range of stakeholders that can be influenced to invest-either directly or indirectly. By refashioning the business model or case to create a more inclusive process we provide business and government with a powerful tool to communicate strategic choices around NBS. We note that the economic risk will vary with the type of solution, targeted resilience outcome, level of investment, scale of actions, and the lifespan of the NBS. Performance measures of NBS will vary with time and scale leading to shifts in the level of resilience, and therefore risk mitigation over time. This can be either an improvement or deterioration in performance during the project lifecycle. The level of acceptable risk will be modified by the level of return on investment, which is often difficult to discern for NBS, with significant benefits often not quantified, monetized, or not included in the business case or risk-return performance analysis. Defining the business case is thus often problematic.

While we continue to formulate business cases where the inherent value is based on the exploitative cost of environmental, social, and economic externalities, rather than being an inclusive basis for investment, we will continue to promote cost shifting to different locations, across time or between actors, governments, businesses and communities, in which the burden is borne by the environment and losses become intergenerational. As such, the focus on business returns (i.e. profits) is a model that may not be fully inclusive of benefits or co-beneficiaries.

Evidence in the literature promotes alternative outcomes and suggests there remains an opportunity to create a structure, model, or framework in which these benefits are valued, captured, realized or understood. By the modifying business models to be inclusive of NBS, in-tangible values and benefits, we can redefine the ways in which society creates, delivers and captures value, resulting from strategic choices and in accordance with long-term sustainable development. This business case or analytical framework should be based around core elements linked to the spatial-temporal evolvement of NBS, the stakeholder engagement process, and the level of investment that is supported by the basic principles of value creation, value distribution (co-benefits), differentiation in the market place and the delivery of alternative revenue streams.

Financial Case

When looking at market opportunities and potential business policies for fostering the deployment of NBS, a primary entry point is the value of the ecoservices that they can provide. These include natural capital assets that provide services and a range of provisioning, regulating and socio-economic benefits, which include the improvement of air, water and soil quality, health benefits, biodiversity support, climate regulation, flood risk reduction, educational and recreation opportunities, as well as non-use values such as aesthetic values (Perrin 2018, Vivideconomics 2018). However there remain key barriers that must be overcome, from institutional inertia to first-mover disadvantages and a resistance to change.

Political and business vision and leadership is needed to transform the business-as-usual investment pathway from traditional-classical economics based on simple profit-loss evaluations to more inclusive low-carbon NBS. (World Economic Forum 2013). However quantitative estimates of these benefits and performance metrics are often not available, therefore there is a lack of a proven track record for most NBS, in regard to their revenue-generating capacity.

Underlying this is the continued uncertainty associated with the regulatory or policy environment across all levels of government and remains a potential risk for the establishment of innovative financial instruments such as SIBs, EIBs, or other alternative Bond structures. Furthermore, NBS while heavily promoted are relatively new to investors, whose tendency is to be cautious and over-estimate risk simply out of lack of knowledge and experience with uncertainty consistently cited as a potential obstacle for widespread adoption of these structures (Green Finance Taskforce 2018).

Transformational Change

In driving society, commerce and communities towards a globally sustainable future, one that is necessary for the continued planetary well-being, a transformation is necessary, one based on the strong interconnectedness of other aspects of natural solutions, such as resilience, transition, adaptation and adaptive capacity (Thaler et al. 2019). There is a fundamental requirement to shift away from the present need to focus on biophysical and economic quantification and methods, which has occurred at the expense of a more comprehensive social understanding of environmental impacts and barriers to change—including the role of power, social class, geographical location, historical change, and achieving human well-being (Pirgmaier and Steinberger 2019). Thus, to promote the global implementation of NBS, and a shift towards sustainable economic development based around a more inclusive, socially and environmentally focussed economy, there is a requirement for an extensive societal transformation which provokes an extensive change of the present economic and values system. This transformation will be required across all scales of the economy, community, cities and state.

Chapter 2. An operational and financial framework for developing the NBS Business Case

The European Commission-funded "ThinkNature" project has proposed an NBS business case framework that will enable proponents to conduct a comprehensive analysis of the potential co-benefits, stakeholder linkages and economic efficiencies associated with Nature-Based Solutions (NBS) related investments. The framework will promote the development of strategic business cases that account for and internalize other environmental and social costs and benefits to society (positive and negative externalities) alongside the more 'traditional' financial components. This chapter, in part, addresses these challenges by presenting the generic framework and associated criteria that need to be considered when estimating the broader influence and performance of NBS. We provide an example of application of the framework, and two examples of a Cost-Benefit Analysis using case studies. An overview of methods that can be used to value non-market benefits generated by NBS is also provided and accompanied with concrete examples. A summary of the types of data and NBS design information required to prepare a business case for NBS and how this data and information may change between finance mechanisms is also presented.

2.1. Introduction.

The focus of this chapter is to create business models, analytical frameworks or business case scenarios for NBS and for NI that will communicate to a broad range of stakeholders, an understanding of, and the promotion and implementation of, integrative natural solutions. The implementation of GBI or Hybrid GBI (i.e. grey-green-blue), NBS into urban and rural landscapes is expected to act as an enabler for society to address a variety of environmental, social and economic issues in sustainable ways. These actions, which are inspired by and supported by natural systems, involve using and enhancing existing natural solutions to solve the expected and emerging challenges arising from climate change and urban growth. These solutions should explore contemporary and novel innovations that build-in or enhance resilience and sustainability into urban environments and multi-cultural lifestyles that will enable communities to cope with environmental extremes caused by our anthropogenic activities.

There is an expectation that NBS will be energy and resource-efficient, and resilient to climate change, but to be successful they must be adapted to local conditions and communities while providing incentives and co-benefits for implementation that are often beyond the scope of the simple or classical business case or on-ground activities to capture. We have evaluated material, social and financial mechanism that could support a broad range of proponents to develop business cases and investment options, or at the very least we provide a framework for assessing NBS (including NI, GBI and HGBI) options within communities, business, local government and the wider society, to create multi-functional synergies between intervention strategies and short, medium and long-term goals (or actions).

2.2. Why use NBS and what are the key issues?

In the last decade, so as to address challenges associated with climate resilience, health and well-being in urban areas, current policy platforms are shifting their focus from ecosystem-based to a more broadly termed NBS approach (Nature Editorial 2017, Nesshöver et al. 2017, Calliari, Staccione, and Mysiak 2019). Thus, in terms of providing ecosystem-services (ES), implementing NBS should result in the provision and capture of the broader co-benefits generated from this type of multifunctional innovative build, such as the improvement of place attractiveness, of health and quality of life, and the creation of green jobs. NBS, therefore, are directly relevant to several policy areas and through their systemic nature interact with many others, such as land use and spatial planning (Calliari, Staccione, and Mysiak 2019). However, few frameworks exist for acknowledging and assessing the value of the co-benefits of NBS, and fewer still, to guide cross-sectoral project and policy design and implementation (Raymond et al. 2017).

NBS have the potential to link policies such as climate change, mitigation and adaptation, disaster risk reduction, sustainable management of water resources and energy efficiency; and at the same time, they can enhance biodiversity, natural capital, low carbon economic development, social welfare and community health and well-being (Nelson, Adger, and Brown 2007, Nesshöver et al. 2017, Raymond et al. 2017, Browder et al. 2019, Calliari, Staccione, and Mysiak 2019, Coles et al. 2018, Thaler et al. 2019). However, to achieve this, it is important to understand how current real or perceived barriers around NBS investment prevent uptake. In this chapter we discuss the financial instruments, policy and regulatory tools, business cases for NBS implementation; and describe a new approach to modelling NBS projects that will promote the uptake of sustainable solutions. We have provided guidance for computing NBS-performance indicators, such as net present value, that account for marketed benefits and for the broader range of benefits delivered by NBS. However, designing this type of guidance faces difficulties in: a) writing a single guidance document that fits all types of NBS; b) adapting the content to the targeted funding mechanism; and c) the lack of consideration of non-marketed benefits in building a classical business case. The following section provides a review across the scope of NBS with a focus on identifying the key elements of classical business cases that can be transferred to promote NBS.

2.3. What are the key elements of business case?

An economic or Classical Business Case (CBC) is a type of decision-making tool used to determine the effects a particular decision will have on profitability. According to this simple interpretation, the business case is then synonymous for NBS, *'if an NBS project is implemented and delivers any commercial benefits to a company, in a reasonable timeframe'*; we can then say that the CBC for NBS has been established. In this iteration the commercial benefits may include:

- An increase in profit;
- A reduction on maintenance;
- Mitigation of (operational) risks;
- Improved reputation (if good, increased customer engagement);
- An increase in land value, and
- Creation of a new revenue stream (new business opportunities, e.g. a café or bar).

A strategic element is normally included in any CBC, which describes the strategic need for the project, with consideration given to:

- What options were considered before this course of action (the project) was adopted?
- What benefits will the organization receive once this project is complete?
- How long will these benefits take to achieve?
- What is the Internal Rate of Return (IRR), cash flow and payback period?
- What is the project estimated to cost and how will this be funded?
- What is the Return on Investment (ROI) based on the expected benefits and costs?
- What are the risks that could affect the business case?[19]

However, while it may be nice to have developed a case for an NBS project, if there are no commercial benefits the project is unlikely to be implemented. While the "Classical Business Case" delivers a reasoned case for initiating a task or project, outlining the details on costs, associated risks, as well as pros and cons, alternative options, actions to take as well potential barriers, and the predicted timescales over which the

[19] https://expertprogrammanagement.com/2017/06/project-business-case/

project will be completed, it may not necessarily capture all the benefits or value delivered. Above all, a good business case must have a compelling conclusion, and it *should define the risks of what might happen* if no actions are undertaken (i.e. the BAU case). Thus, this becomes the justification for a proposed project or undertaking and is based on the expected commercial benefit, which largely ignores the potential non-monetized cultural-socio-ecological co-benefits or dis-benefits that may accrue through implementing the project. Therefore, it follows, that the suggestion here is, there is an identified need to overcome strictly financial aspects of Cost-Benefit Analysis and CBC analytics that are buried in our evaluation methodologies, governance structures and economic approaches.

So given that we have models for purely identifying financial benefits on which commercial decisions are based, and there is evidence that there are both pure NBS and human/industrial solutions (HIS)-(see Figure 8); we recognize that the majority of implemented solutions are nominally a mixture of both (Schaubroeck 2018).

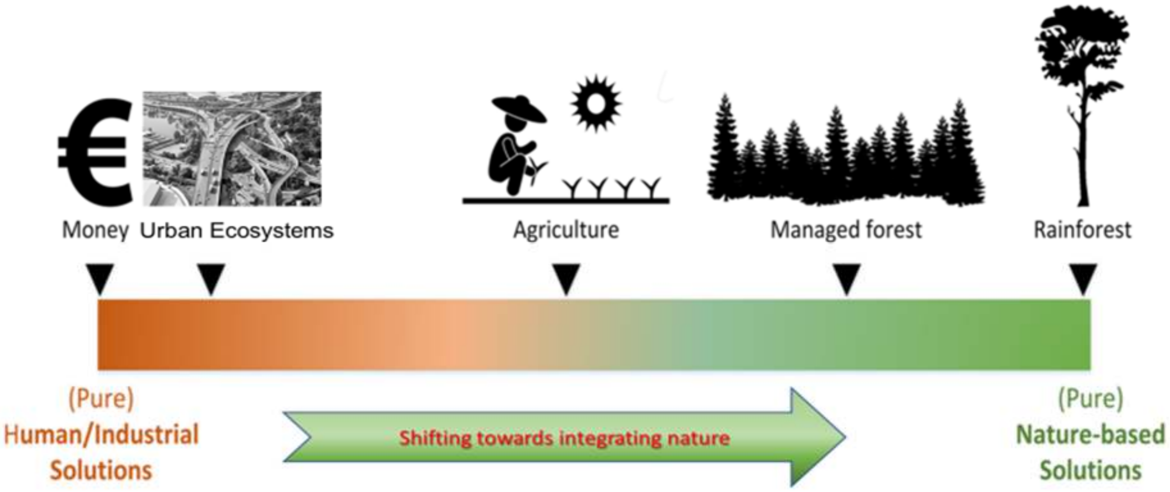


Figure 8. Depicts the range of projects that could be implemented from purely human-industrial to natural solutions, with the majority of 'project' or activities falling in the middle range as hybrid combination of grey-green-blue projects (HGBI). The Paris Agenda is providing the policy framework to move towards more HGBI projects that provide broader community and thus societal benefits while improving ecosystem and infrastructure resilience. (Adapted from Schaubroeck 2018).

As there is no definitive or standard NBS, the recognition that there is a natural component to the project (along with other elements) is a process that can be used to capture or frame the additional benefits delivered through NBS. (Nesshöver et al. 2017) among others notes that: "*The existence of a variety of ways to frame and define the NBS concept is not necessarily problematic, as long as each case makes explicit its rationale and particular interpretation of NBS.*"

Understanding the wider benefits (co-benefits) of NBS is a significant factor in capturing both the monetized and non-monetized aspects of a project or programme. The focus on the financial aspects (i.e. through ROI, IRR, profitability) obscure other elements of potential benefit (or profitability) that may be used to engage alternative stakeholders. A preliminary analysis suggests therefore that there are some fundamental elements to framing the business case for NBS and their deployment as part of shift towards more natural infrastructure (NI) and urban ecosystem (as listed in Box 3). As such, to move beyond the purely capital return-based models, to improve investment opportunities and promote benefits (profitability) of NBS, there is an identified need to overcome strictly defined financial aspects of CBA & BC Analytics.

Box 3. Key performance options to consider for nature based solutions. Adapted from (WBCSD 2015).

What are some of the potential benefits Nature-based solutions?	
• Can be cost-effective • Address resource limitations • Increase infrastructure resiliency • Provide an avenue for adaptation to a changing climate • Deliver co-benefits	• Improve stakeholder and community engagement • Increase educational and recreational opportunities • Improve ecosystem function and maintain biodiversity • Improve community health and well-being, and resilience

2.4. Developing the Business Case for NBS

Natural infrastructure (NI) incorporates both the natural environment and engineered systems (or grey infrastructure) to provide flood, fire and drought risk reduction, clean water, and clean air benefits that utilize natural processes or system functions. NI as part of an NBS can also deliver economic, societal and environmental benefits, such as improved or maintained water quality, vegetation, soil health, land protection, land management, and other elements. NBS can therefore be designed and applied at different scales and deliver benefits across variable time increments (years-decades). By deploying NBS or more broadly nature based projects there is an expectation that damage and impacts can be minimized and communities can recover more quickly from disasters.

Defining the NBS business cases is often problematic, as elements of the project can accrue benefits across the whole of life cycle, not just the infrastructure construction phase. Issues arising from continuing management, maintenance, independent group co-ordination (or facilitation), NBS standards, performance metrics (or indicators) remain as obstacles to be addressed during the planning, design and post-implementation phases. The revised business case framing suggested here for NBS implementation is one that supports broader integrative (stakeholder) engagement to deliver climate resilience and recognizable environmental and health and well-being outcomes. We suggest that these projects are therefore best represented through a multifunctional provisioning narrative, such as a strategic case (mapping) analysis that has a focus in flows of value rather than neo-classical economic structures (Pirgmaier and Steinberger 2019).

Thus, there remains an opportunity to utilise such an operational structure, model or framework in which all benefits and values (created or captured) can be realized and the performance criteria are more fully integrated and defined. By examining the elements of the CBC, we can extract the key elements in identifying the potential of a project to deliver returns.

A CBC provides:

1. Provides the justification for undertaking the project;
2. Highlights the alternative options and identifies the risk, benefits and costs;
3. Demonstrate value;
4. Provides evaluation of options and alternates to proffer a preferred solution for a given timeframe and spatial scale.

We also suggest that projects should be contextualised in terms of what the outcome may be if the project is not implemented. This is particularly important if we are considering managing the impacts of externalities (e.g. climate change, extreme events) and designing resilient sustainable solutions. As we shall see this has implication for NBS projects in terms of delivering a wider external agenda, rather than a simple focus on monetary returns. This redefinition of the CBC requires bridging silo gaps between, finance, investment strategies, governance, regulation, social, ecological and technical agendas; to recognise the multi-functional performance elements of systems that provide greater support for societal and environmental well-being, rather than the current practice of one dimensional resource exploitation.

We suggest that the content of the business case should be adapted to reflect the specific project requirements and context. So, using the CBC we know that the key elements are, a) Making an informed decision; b) Assessing the potential risk, relative to returns on investment; c) Determining the profitability of a project. Therefore, we need to consider the scope of the decision-making process, the potential for NBS to perform against the risk of failure or loss; and what is considered to be the profitability – or more importantly in the case of NBS, the '*profitability or value'* captured in the co-benefits delivered by the project. This leads back to the scope of the project and deciding the breadth of co-/dis- benefits that have been identified, relative to the potential to deliver monetised returns strictly as profits. As we have iterated earlier, there exists an opportunity to reclassify 'profitability' and look to delivering the co-benefits that accrue from multifunctional projects. This also requires the reconfiguration of the existing economic cycles of investment, governance and policy across all levels of society if these co-benefits are to be defined, quantified and delivered.

In providing a framework for this type of decision-making process we can identify both the internal and external beneficiaries, which can lead to the engagement of alternate or additional stakeholders that would contribute to a project that a classical business case evaluation may exclude. By assessing and monitoring the interdependencies between potential projects across various temporal and spatial scales, and by linking co-beneficiaries that may develop external to individual projects, we ensure that interactive elements and non-monetised benefits can be identified and communicated. For example, we use peatland restoration and Natural Flood Management (NFM) in subsequent sections to illustrate the application of broad-based cost benefit analysis (CBA), linked with the valuation of ESs to an NBS.

Climate change represents a major justification for many peatland restoration activities, but also increases the vulnerability of peatland ecosystems. Peatlands contribute to preserve a substantial carbon stock, and to sequester it in the case of healthy peatlands. They also generate other essential ES such as water regulation, provision of cultural services, and habitats for wildlife. Rewetting and restoring peatlands play a fundamental role for human well-being in providing NBS for society, through mitigating climate change, in particular. NFM on the other hand corresponds to the use of natural means to reduce the risk of flooding. NFM strategies include increasing soil infiltration to reduce surface runoff, using ponds, ditches, or land to store water, and planting woods reduce runoff. Using this approach contributes to water resource management, flooding risk reduction, and climate change adaptation.

2.5. Key issues for NBS implementation

NBS approaches have been recognized as providing multiple benefits including increased resiliency and adaptation to a changing climate, (WBCSD 2015) but their uptake has yet to be mainstreamed in such a way as to have the desired significant widespread impact on communities that is increasingly necessary.

One reason for the limited uptake resides with the CBC approach to NBS projects and that local actors and stakeholders often pursue initiatives to address local problems or to seize local opportunities, rather than to contribute to a broader societal transformation. Key barriers to adoption and transformation in these instances relate to: a) lack of local capacities, b) lack of local political support and c) technological challenges in the implementation phase (Thaler et al. 2019). Further analysis of barriers to NBS uptake and implementation concluded that

1. NBS and stakeholder engagement should be promoted using:
   - Mainly bottom up approaches;
   - Leadership at different levels; and
   - Transfer of knowledge through demonstration.
2. NBS has been promoted as providing multifaceted solutions and benefits with limited support on evaluation tools, performance metrics and risk analysis
3. By combining skills – knowledge - motivation with governance and coordination then better implementation outcomes can be delivered to support biodiversity resilience and human well-being (Mortimer et al. 2019)

We postulate that there is an identified need to provide wide range of resources to improve the understanding of the NBS Business Cases and to upskill those that are likely to participate from both bottom-up and top-down perspectives to encourage joined up thinking. Whether this led from the public or private sector, stakeholders with a material interest (benefit or loss) in NBS's, we concluded these should be mapped out, so as to understand what the business case is and what beneficial linkages or co-benefits spinoffs might exist. This would enable the delivery of a transformative behavioural change that is fundamental necessary for humanity and the planets well-being (Thaler et al. 2019), by framing the connectivity and context through an analytical framework that shifts the value proposition from a purely monetary focus to an broader socio-ecological-technical foundation.

Thus while there exists an acknowledged capacity-skills-governance deficit their uptake is also hampered by a number of barriers that relate to the value proposition,[20] value delivery[21] and value capture[22] of existing NBS business models and available sources of (public/private) finance ((Toxopeus and Polzin 2017). We

[20] Identifies the services or benefits that are created and are desirable to the consumer or beneficiary.
[21] Maximizes the benefit or service delivered to the beneficiaries at a competitive cost.
[22] Generates sufficient benefits (profits) to ensure that value created is returned to ensure business viability

have established then, that in such cases alternate methods of finance and/or business case/model scenarios are required. We could also add to the evaluation process some elements that fall outside the scope of the CBC such as:

- Who benefits from the project -directly and indirectly?
- What impacts does the project have on carbon emissions?
- What contribution does it make to national initiatives and the Sustainable Development Goals?
- What level of resilience, sustainability and biodiversity elements are present?
- Is there potential to upscale or downscale elements of the project?
- Are there niche and synergistic opportunities with other projects?
- What is the socio-ecological-technical elements of the project and how are they valued?[23]

Given these elements the question then becomes -Why choose an NBS? Our examination of the broader GBI-Hybrid infrastructure investment options and trends, suggests that increasingly adaptation opportunities will be the driver for change, given the slow pace of mitigation, policy and economic reforms, alongside other externalised national agendas (e.g. decarbonisation of the economy) and global policy drivers (such as the SDG's, Agenda 21) and the implications of the increased speed at which climate change impacts are occurring. The spectrum of options shown in Figure 1, is covered in part and described through the IUCN NBS Typologies. Type I- No or minimal intervention in ecosystems; Type II-NBS for sustainability and multifunctionality of ecosystems; and Type III-Design and management of new ecosystems, but excludes larger hybrid GBI or eco-bio-human-industrial solutions, circular-reuse solutions, which we define as Type IV, to provide a broader range of NBS that may be sculptured to provide fit for purpose options, and funded through innovative financial models or blended financial instruments.

2.6. Informing the design of funding mechanisms

Amid increasing pressures on public budgets, the slow recovery of the global economy and calls to improve the efficiency of public spending, there is a growing justification for the creation and develop of more innovative approaches and mechanisms for financing NBS (Illes 2017). Furthermore, as climate change related impacts on the global economy, urban landscapes and communities, and the functionality of ecosystems the need to leverage additional resilience funding from the different sectors of the business community, corporations and private sector becomes increasingly substantive (Illes 2017, Lafortezza et al. 2018, Resilient Cities 2017). Innovative financing mechanisms, such as agri-environmental schemes or

[23] See Table 7 for applications of these elements as part of the BMC case assessment procedures.

Payment for Ecosystem Services (PES),[24] habitat banking, integration of natural capital into innovative fiscal instruments and different financial mechanisms to leverage private funding are alternative options that can offset the burgeoning gap between financing needs and capacities to address them. Tables 2-4 in Chapter 1 above summarise a number of financing mechanisms that are potentially suitable for NBS, depending on the characteristics and needs of specific projects. In this section we focus on presenting and applying methods of Cost-Benefit Analysis as a generalised quantitative analysis component of NBS Business Case development, regardless of financing mechanisms. The implementation mechanisms that is considered by example is PES.

As noted in Capter1, payment schemes such as PES are based on the idea that beneficiaries can compensate land managers for changes in land management practices to secure the delivery of ES. For example, downstream beneficiaries can invest in peatland restoration upstream to ensure the delivery of hydrological services in the catchment. Figure 9 illustrates the theoretical minimum and maximum levels of PES to incentivise a change in the land use, for the case of peatland restoration. The minimum payment is the difference in private returns between the current and the envisaged land use and is equivalent to the opportunity cost and the transaction costs incurred by the change. The PES maximum value is determined by the value of the services provided by the NBS. In other words, it is at maximum equal to the overall social value that society would obtain if all ES were realised. In practice, the PES may lie anywhere in between these two extremes (Figure 9). However, PES differ with regard to the type of ES targeted, the sources of the financing, the ES provider(s), the duration of the payment, and the allocation (actions or outcomes-based activities).

The actual implementation of a PES scheme necessitates: a) participation of all relevant stakeholders and identification of who benefits and who is willing to pay; b) clarity over the property rights; c) adequate monitoring system; and d) careful design of contractual obligations of buyers and sellers of the ES (length, performance measure). Two examples of using PES that differ in their sources of funding (i.e. buyers of the ES) are given below.

[24] PES schemes are advocated in situations in which an environmental externality (e.g., deteriorated water quality due to peatland degradation) can be re-dressed through the creation of ad-hoc markets based on the postulate by which the social welfare optimum might be attained via bargaining (e.g., making payments to farmers in compensation for changed management practice, compensating for the opportunity costs of giving up peatland drainage or burning).

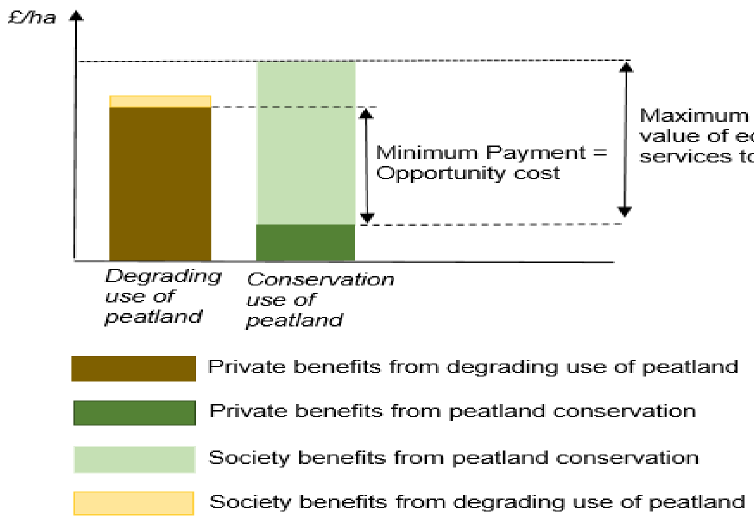


Figure 9. Design of PES – illustration for the case of peatland restoration, after Engel and Schaefer (2013).

Example 1. The water company United Utilities set up a **Sustainable Catchment Management Programme** (SCaMP) in recognition of the hydrological services provided by peatlands and is the first PES scheme financed through the UK water industry. The scheme aims to protect and improve water quality in the water resource catchment, to avoid additional water treatment costs. The project entails a number of interventions to be implemented in United Utilities owned catchments, which largely consists of upland moorland. Financing is provided by **United Utilities customers** through increases in their water bills and by public agri-environment payments within Country Stewardship schemes. For instance, for SCaMP 1 (2005-2010), United Utilities invested ca. €12 million in moorland restoration, woodland management, farm infrastructure improvements and watercourse protection across 27,000 ha.

Example 2. The **Peatland Code** is a voluntary standard for UK peatland restoration projects issued by the UK International Union for the Conservation of Nature (IUCN). The Code enables the marketing of climate benefits from peatland rewetting. Landowners can qualify under the Code by proposing peatland restoration projects on their land that meet certain pre-requisites (e.g. regarding peatland type, minimum peat depth, and existing degrading conditions). An independent body then predicts greenhouse gas emissions reductions from these projects, and the Code defines the expected carbon benefits. The landowner of a validated project is responsible for the carbon sale and for the contracts with buyers, which are usually **businesses** motivated by corporate social responsibility. In return for investing, buyers receive pending Issuance Units that are then transferred to verified ***Peatland Carbon Units***. Social climate benefits are thus internalised through these private investments.

Other options providing financial compensations to landowners include:

- ***Easements contracts*** whereby a measure is implemented by a third party that agrees on a permanent easement with the landowner. A one-off capital sum is paid to the landowner and in return, the third part will take an agreed action on the land in perpetuity.
- ***Wayleave agreement***, which is a terminate license for which a third part pays the landowner annual compensation or rent for having access to a particular piece of land for a given purpose.
- ***Community right to buy***, where a community registers an interest in land if a landowner is willing to sell.

2.7. Potential sources of funding and obstacles

Significant challenges exist in encouraging the beneficiaries of the delivered NBS and provisioning services to finance the projects delivering the solutions, with the majority of PES schemes being publicly funded. For example, NFM often provide downstream communities or landholders with the benefit of reduced flood risk (e.g. residents of urban areas downstream), but they may have little connection to those who can influence the implementation of NFM schemes (e.g. rural upstream communities or Utilities). This can lead to a lack of clarity of who is responsible for the flood risks and has ownership the design and the delivery of the NFM measures. For example, the EA Flood Defence Grant-in-Aid offers grants on the basis of households protected from flooding including returns available for the wider benefits but are only funded up to the value of £0.056 per £1 of assessed wider benefit. This becomes an issue for interventions characterized by a few direct beneficiaries (e.g. some land management practices in rural areas).

Another challenge is to motivate private investors that don't see a clear/direct return on investment, although the private sector may become involved through a sense of corporate social responsibility, but this is still far from being a mainstream practice. One way to overcome some of these challenges, and a critical key success factor to the implementation of NFM intervention or other NBS is having a "catchment co-ordinator" or "catchment champion" that will have a good understanding of the multiple factors driving implementation of the NFM and stimulate engagement from others. This could be an individual or an organisation would have a view of the whole catchment, understand the science underlying different NFM measures, the concerns of farmers, and well as the various types of benefits of the potential investment, which would facilitate bringing different funding streams and stakeholders together. Note that NFM projects are often initiated by funding for co-benefits, higher level stewardship through organisation like the National Trust (e.g. habitat creation, utilities companies – and water quality) and through private beneficiary investment (some UK funder details are given in Table 5).

2.8. Barriers to investment

Connecting Nature[25] identified some significant barriers to adopting and investing in NBS which include both financial and technical elements of NBS projects. Additional aspects of this have been identified by other researchers assessing the effectiveness of NBS for infrastructure, resilience, adaptation and mitigation. Even in situations where there is considerable interest in implementing NBS measures, there are several barriers to securing funding. These include: a) uncertainty about its duration and opportunity costs; b) complexity of bureaucracy associated with funding applications; c) uncertainty over risk allocation and responsibility; d) transaction costs of discussing and negotiating between multiple parties; and e) lack of consideration for co-benefits or services provided by NBS to communities.

We have noted that **t**here is concerted shift more towards adaptation-resilience to deliver more immediate action (and impact) to counter the slow pace at which mitigation measures are being implemented globally. Connecting Nature and other researchers (e.g. Grow-green, UnaLab) have identified some of the **major challenges** to innovation in NBS financing and business models, along with other elements we have identified as influencing the implementation of NBS. These include:

Table 5. Examples of potential sources of funding for NFM measures in the UK

Funding for NFM measures	Description
Heritage Lottery Fund	Provides leadership and support across the heritage sector, and advocate for the value of heritage; Extends understanding, valuing and sharing our heritage brings people together, inspires pride in communities and boosts investment in local economies
SEPA water environment restoration fund	Mainly contributes towards achieving WFD benefits and only considers NFM benefits if those are secondary to WFD benefits
Scottish rural development programme	Funds woodlands creation in Scotland
Rural development programme for England	Offers a flat rate per year and per ha for the implementation of specified management options
Forestry Commission	Helps cover investment in woodland creation and woodland for water funding
Local Authority Capital Funding	Funds NFM measures in Scotland if those are presented in a flood risk management plan

[25] Connecting Nature is a €12m five year project funded by the European Commission's Horizon 2020 Innovation Action Programme. https://connectingnature.eu/

1. **Focus on capital investment** without considering the sustainability of the NBS business model. Who's going to pay for the additional management and maintenance of NBS projects after the capital investment phase?
2. **Path dependency** on the same sources of financing for NBS: NBS are mostly funded from public sources (city, regional, national, European). The pressure to meet disparate public funding requirements has led to the emergence of 'Frankenstein' projects not meeting the original NBS project objectives.
3. **'Silo' gaps**: Internally there is a lack of financial planning & business model expertise in the environmental and planning department. There is often a lack of alignment between public sector departments e.g. economic & tourist objectives v environmental & planning objectives. The interests of external stakeholders, beyond immediate residents, are often unexplored.
4. **Lack of experience** in using public procurement to stimulate new innovations/markets.
5. **Pressure to pursue public-private partnerships** without considering social or environmental trade-offs.
6. **Complexity of governance hindering innovation in business models:** NBS often involve multiple public agencies, NGOs, residents and it is difficult to align different stakeholders to a common vision and engage stakeholders in ongoing governance and business model arrangements.
7. A lack of **understanding of the NBS value proposition**, value delivery and value capture within the classical business model.
8. **Limited available sources** of (public/private) finance and the level of complexity associated with these schemes (both low- & high-end financial instruments).
9. Difficulty in identifying **the mechanism for the repayment** of funding (or ROI).
10. Difficulty in **quantifying direct benefits** that are less tangible human well-being co-benefits and more long-term.
11. **Capacity-skills-governance deficit** in local capacities, local political support and technological challenges.

Moreover, Connecting-nature have also identified the deficiencies in the classical business case, business strategies and investment models. They suggest how the disparity can be overcome through novel, innovative and co-operative approaches to design, policy and implementation opportunities for NBS. These include:

1. **Reversing the focus** on financing capital investment and move towards a business model that focusses on long term sustainability and the additional co-benefits delivered by NBS.
2. **Broadening the value** proposition to include a focus on environmental, social and economic benefits, the identification of new stakeholders and alternative ways of capturing value. This approach may lead to the identification of new sources of financing, investment or in-kind resource provision.
3. **Bridging 'silo' gaps** – both internally within public sector organisations and externally with different stakeholders, to build a common vision and broader understanding of NIS-NBS potential benefits for all stakeholders.
4. Using the **NBS Business Model Canvas** to facilitate capacity building and skills identification.
5. Identifying **trade-offs** between economic and other considerations that can be used in developing different value recognition and value capture propositions.
6. Using an NBS Business Model Canvas to enhance the **identification of all key stakeholders** that could be involved and provide a pathway to engagement through different governance, planning and financial models.[26]

Connecting Nature have shown (Figure 10) that the basic elements of a CBC can be captured. Here the phased nature of the classical business case modelling is described with each sector broken down that offers opportunity for development within the ***business model canvas*** (BMC) first developed by (Osterwalder and Pigneur 2010). By breaking the project deliverables into time vs cost scales (Figure 10), based the work done to achieve these outcomes, the project can be broken down to reveal the potential resources commitment using single business case strategies for these individual project elements.

This creates an opportunity to identify key stakeholders, the level of investment and the expected interdependencies within each segment While these single elements are important once in the project development phase, it is important to remember that other factors need to be considered at the strategic phase that will allow the identification of a broader number of stakeholders, investment opportunities and multiple projects over extended temporal scales of planning, financing, building, operations and maintenance as we explain in the following sections.

[26]Adapted from Connecting Nature. https://connectingnature.eu/financing-and-business-models

2.9. Cost-Benefit Analysis

2.9.1. Using Cost-Benefit Analysis for decision making with NBS

A Cost-Benefit Analysis (CBA) is a decision support tool to help compare the economics of alternative management scenarios, including the option to do nothing. A CBA can be applied to understand whether investments in NBS generate net benefits to society, and how these net benefits compare with the ones from alternative scenarios like the implementation of grey infrastructures, so that social welfare can be maximized through the most economically efficient allocation of resources. CBA is based on understanding whether the benefits of a given scenario are larger than its costs, helping to support decisions on expenditure (e.g. prioritise interventions), design incentive mechanisms and attract funding.

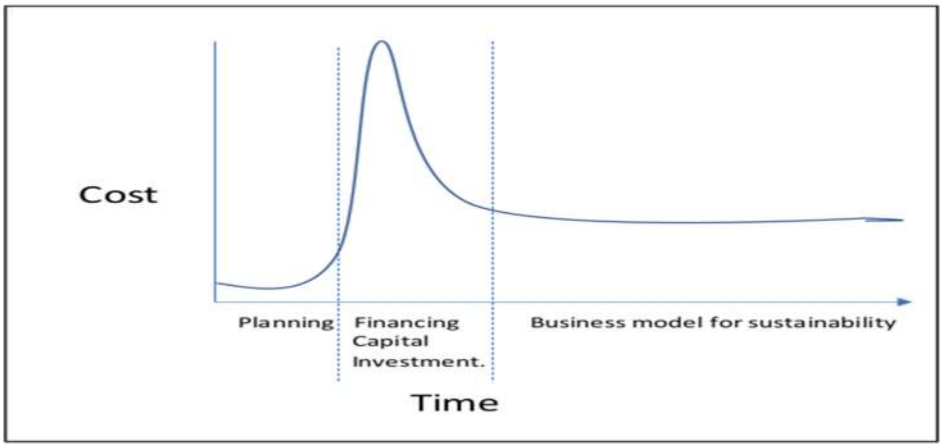


Figure 10. Stylized distribution of costs, investment need and time required to develop, deliver and maintain an NIS-NBS project (adapted from Connecting Nature, 2019).

2.9.2. A Framework for the Cost-Benefit Analysis of NBS

A comprehensive CBA calculates, in monetary terms, the costs and benefits of each alternative considered (whether a NBS or not), including both the private and the societal costs/benefits (Figure 10). Thus, not only are the costs and benefits incurred by the business investing in the NBS considered, but also the costs and benefits to society are reinternalized in the analysis. In this way, the CBA also allows for market distortions arising from, e.g. market imperfections, externalities, taxes and subsidies to be assessed and included. In the context of "living infrastructures" like NBS, valuation of positive externalities is particularly important because of the significant wider benefits that they are associated with. Figure 11 below lays out the steps considered in a CBA.

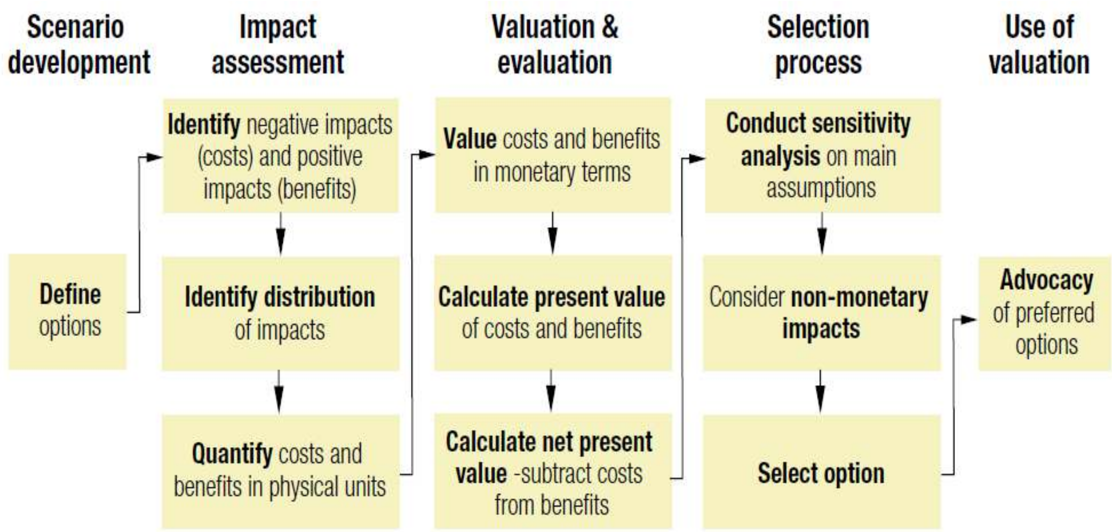


Figure 11. Main steps in performing a CBA (source: van Beukering et al. 2007)

2.1.1. Description of the CBA process as applied to NBS projects

Initially, the boundaries of analysis need to be defined and scenarios of change need to be developed. The latter involves projecting changes/impacts in the ecosystem/area into the future across the alternative management scenarios considered (e.g. baseline, NBS implementation). The changes need to be assessed biophysically and quantified with respect to impacts on the level of ES provision, over space and time. ES provision levels (flows) under a given scenario are compared to a baseline or counterfactual scenario. This also includes delimitating uncertainties associated with this change (e.g. resulting from climate change, economic context, policy drivers).

Secondly, the economic assessment includes the monetary valuation of both the benefits and costs related to ES provision to estimate social welfare changes generated by a change in ES flows due to the envisaged scenario. The present value of these costs and benefit, and then the Net Present Value (NPV) are then calculated. NPV is one cost-benefit estimate that allows the computation of the net benefits of a particular management scenario. This reflects the measure of the entire stream of net benefits from a scenario (e.g. NBS) over a particular time frame (e.g. 10, 50 years), and represents the present value of a given stream of costs (C) and benefits (B) over some future time-period (t). Thus, NPV acknowledges that both costs and benefits extend over time (e.g. benefits of carbon storage are realised as long as the peatland accumulates carbon). The unit used for the benefits needs to be the same as the one used for the costs (e.g. per hectare). Through discounting (r), NPV accounts for the reduction of value for returns/benefits placed further into the future. Recommended discount rates for environmental projects usually vary between 3 and 5% (but it should be noted that choice of discount rate is debatable – see section 7.2)

Comparing NPV estimates of different scenarios (e.g. with/without NBS, different types of NBS), or across different sites thus helps select the best option for the delivery of social value. The NPV is calculated as follows:

$$NPV = \sum \frac{(B_t - C_t)}{(1+r)^t}$$

Thirdly, since cost-benefit estimates are sensitive to variations in inputs, assumptions, or the manner in which the analysis is set up, sensitivity analysis of the outcomes of the analysis is recommendable. This includes accounting for the effect of changes in a) population, b) physical boundaries of the analysis, c) the outcomes of biophysical assessments of the impacts of the scenario (e.g. due to errors in biophysical models), and d) the assumptions and measurement errors associated with the valuation process and the choice of discount rates. Importantly, the accuracy of the CBA will depend on the accuracy of the value estimates upon which it relies.

Lastly, cost-benefit estimates can be used in combination to other indicators of performance, such a Benefit Cost Ratio (BCR) and return on investment (ROI).

2.1.2. Key criteria require to conduct a CBA for NBS

Conducting a CBA requires a strong understanding of the conditions of the ecosystem, including ecological impacts of the different management scenarios and consideration of interconnections with other ecosystems or at different scales and the type of NBS to be implemented. The ideal economic appraisal considers all costs/benefits and assesses them in a transparent and consistent way, normally using a monetary metric to allow comparability of options for the decision-maker. In addition to a CBA, other considerations such as risks and distribution effects are relevant when deciding between management options, scenarios or projects. Thus, Step 2 in the above CBA framework requires the identification of the beneficiaries and affected stakeholders (OR cost bearers) by the NBS or management scenario considered, the appropriate time and spatial scales, a suitable discount rate, and the potential sources of uncertainties. This is detailed in below, with examples.

- ***Private and societal benefits and costs***

A quantified assessment of the conditions of change in the delivery of benefits and costs, along with a comprehensive valuation of these variables is fundamental to the design of the business case. The economic valuation of ES is based on the concept of total economic value (TEV), which reflects the idea of accounting for all aspects of ES in terms of the benefits that they provide (see Figure 12 as it applies to a peatland case study). The TEV of a NBS therefore consists of the economic values of all the ES delivered, including market and non-market ones, options values and existence values. For further TEV examples of the concept applied to wetlands see (Emerton 2016).

- ***Beneficiaries and affected stakeholders***

In the assessment of NBS scenarios, it is desirable to identify the individuals who will either benefit or be affected, i.e. who would bear the costs. Understanding who may gain or lose under various scenarios will provide insights into the social and economic factors that influence current management values and preferences for future developments. CBA typically looks at overall social welfare impacts in order to select the option that generates the highest social welfare. This implicitly assumes that some mechanisms could be put in place whereby 'winners' can compensate 'losers'. Defining the population of beneficiaries and the distributional effects of NBS can be particularly challenging, especially for water-based solutions. Specifically, regarding the definition of the relevant extent of the market and distinguishing between user and non-user values. While the average values may remain undisputed, the population of beneficiaries across which these values are added up may result in very high or low values depending on the chosen market size.

- ***Spatial scale of costs and benefits delivery***

Delivery of benefits and costs vary in spatial scale. For example, while costs of interventions are usually borne by local land managers carbon sequestration has global benefits in terms of climate change mitigation, whereas recreational benefits accrue mainly to regional, and to a lesser extent national, stakeholders. Yet, an understanding of where recreationists live and travel from is necessary to understand how these benefits are distributed across stakeholders. Similarly, water quality improvements may increase water quality downstream, hence the benefits are not enjoyed at the site itself and the economic analysis will have to focus on the preferences of downstream water users. Understanding where the ES flows are produced across a landscape and where the costs and benefits are delivered and how they are distributed help to ensure that all of them are accounted for and internalised in the decision-making process, to define the spatial boundaries of the CBA, and to identify and understand conflicting preferences over management scenarios among stakeholders. This is important as differences in the spatial distribution of benefits and costs may imply that a particular NBS has net positive benefits at the aggregate level of the society but net losses on the individual level. This also implies that policy plans for encouraging a type of NBS that only considers local benefits may not provide optimal results at larger scales.

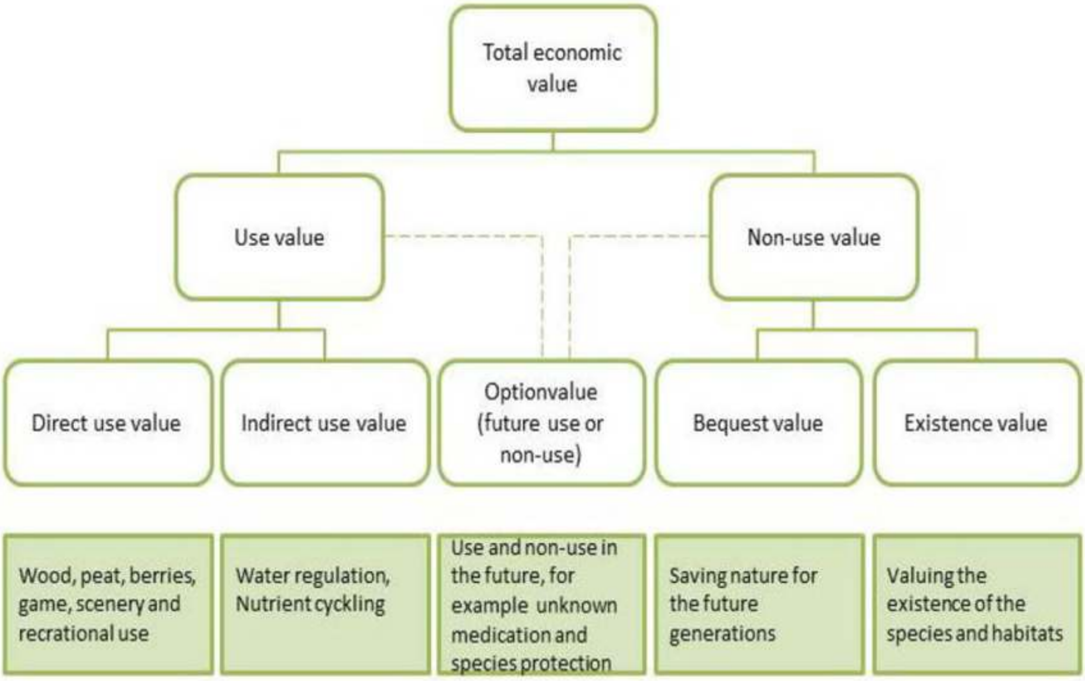


Figure 12. Components of total economic value (TEV). The 'use value' provides benefits instantly, either directly or indirectly. The 'option value' measures the valuation of the future benefits (e.g. valuing an option to use as a site for recreation in the future), and those ES for which the importance for future generations is not yet known. The 'existence value' is the value that humans receive from knowing that species or habitats exist. The 'bequest value' refers to the benefits for future generations. Source: Kosenius et al. 2013.

- **Time frame of costs and benefits delivery**

The time frame chosen for the CBA influences the outcome of the CBA, especially when impacts are non-linear over time. The time frame should ideally be set to allow for the ecosystem and its ecological functions to arrive at some state of saturation or equilibrium condition with respect to ES flows, at the risk of otherwise omitting major changes in ES flows over time. For example, rewetting of previously drained peat can initially lead to increased methane emissions that temporarily increase the global warming potential. Over time, however, rewetting results in a net reduction of GHG emissions. Thus, the distribution of ES flows over time needs to be understood for each scenario considered, together with the uncertainty with respect to outcomes that can be expected to increase when longer time periods are considered.

Generally, choosing an appropriate timeframe will be guided by answering how sensitive the outcomes of the analysis are to the choice of the timeframe, and whether longer or shorter time periods would change conclusions about the relative merit of a given management. In particular, opportunity costs are likely to vary over time, along with prices of commodity inputs or outputs. This means that higher commodity output prices or lower input prices will increase profitability, and raise the opportunity cost of displacing agricultural production, whereas reduced profitability leads to lower opportunity costs. This poses difficulties in setting payment rates to compensate for income forgone and incurs the risk that NBS gains are undone if opportunity costs rise significantly in the future, as this may cause voluntary participants in agri-environment schemes to revert to commodity production at the end of a scheme's contract period.

- ***Risks and uncertainties***

The importance of considering risk and uncertainty in a CBA links in particular to the spatial heterogeneity in values of the benefits and costs. Uncertainties in costs and benefits as a result of the implementation of a NBS, may vary (e.g. under alternative climate change emissions scenarios). Accounting for the risk associated with the delivery of ES outcomes includes identifying factors influencing variability (e.g. determine the local conditions that can favour or reduce the flow of ES delivered). In the presence of risk, outcomes in terms of ES can be weighted by their probabilities of occurrence and then related to their respective benefit estimates, to derive the expected value of a given change. This approach assumes risk neutrality of the individuals over the range of different outcomes. If people are risk averse, risky alternatives will not be preferred. This can be overcome by incorporating information on outcome-related risk directly into the valuation methods.

- ***Discount rate***

The choice of a discount rate implies a certain assumption about future preference over the value of ecosystem services, and as such, they are debatable. The choice of the rate is subject to discussion as it raises ethical and theoretical considerations about whether it is appropriate to attribute lower importance (i.e. through the use of higher discount rates) to costs and benefits of future generations in relation to current ones. This issue is very much related to the choice of time frame. Because NBS benefits may take time to be generated, discounting may affect cost benefit estimates in favour of either doing nothing or choosing alternative grey infrastructures, for instance, which may generate higher expected benefits in the short term. In a public policy context, a social discount rate should apply to reflect social time preferences. Use of a (higher) private discount rate may be necessary though to explain current and future land use choices by individual actors. Moreover, when costs and benefits reach beyond one generation, there is an ethical argument for using declining discount rates, i.e. so the values of future generations over longer term benefits (e.g. climate resilience) is not neglected

2.2. Alternate business cases and models

Building on these ideas, we advocate diversifying or broadening the potential stakeholder involvement in infrastructure investment (or other activities). Using this approach, a BMC can be incorporated into a more process-oriented framework that provides both the strategic view and identifies the key elements of the NBS business case for future road-mapping for potential NBS business models (de Reuver, Bouwman, and Haaker 2013) and value creation (Barquet et al. 2011). In adopting this approach we recognise that other additional issues will be created around the availability of expertise. Individuals, community groups, local government and NGOs may lack the necessary capacity-skills-governance to effectively deal with multi-temporal-scaled projects that require complex financial instruments, long-term maintenance, or extended periods (i.e. years) for which no return on investment occurs. In such cases indirect benefits are far more difficult to quantify, particularly for infrastructure adaptation projects as there are no established methods of quantification, and because the benefits tend to include environmental and social benefits, which are generally less tangible and more long-term. The co-ordination and facilitation of the interaction between decision makers with differing perspectives and agency is an additional uncertainty that is rarely addressed, despite the wide recognition that NIS-NBS projects require action at multiple scales and by multiple actors (Roelich and Giesekam 2018).

Furthermore, recent project evaluations (Roelich 2015), 2015; Raymond et al 2018; Roelich and Giesekam 2018; Thaler et al 2019) have identified a need to define a dynamic adaptive policy pathway that will aid the development of NIS_NBS decision support tools and planning methodologies that can provide integrative facilitation at a range of scale and government levels. Providing policy framing will act as an enabler to implementation, shifting the focus from financial returns to more socio-environmental benefit incentives. Roelich and Girsekam (2018) report that considering the alignment between various perspectives, government objectives and investment when developing plans is crucial to success. While there is a strong business case for companies to invest in NIS-NBS; such as providing access to the services that nature offers (ecosystem services) as a substitute to grey infrastructure, fulfilling the same function, being equally efficient, and providing the same level of performance while potentially delivering greater benefits; avenues to deployment may be stymied by a lack of policy initiatives, regulatory disincentives and building code obsolescence. Case studies (highlighted below) have shown that NIS-NBS may provide more benefits than grey infrastructure and by investing in natural infrastructure, companies can reduce costs, improve operations, generate financial gains, or enhance their reputation (Scarlett 2017, UNCTAD 2017, Roelich 2015, WBCSD 2015, UN 2018).

2.3. Key insights to NBS investment

While NBS is often more cost-effective over the long-term than traditional grey infrastructure alternatives, the barriers to implementation are more complex and are linked to change management, education, partnership working, and securing investment for an emerging and less understood sector. As such, significant barriers remain in defining a clear business case and securing financing for NIS-NBS projects are clear prerequisites to successful implementation. For example, multiple actors, with differing motivations, agency and influence, are required to engage in with climate change mitigation as an external driver, but may choose not do so, if proposed actions do not align with their motivations or if they do not have agency to undertake specific actions (Roelich and Giesekam 2018). A number of examples of external drivers for major infrastructure projects is given in Figure 13. However, the economic risk associated with a given project (i.e. Hybrid-GBI) will vary with the type of solution, targeted resilience outcome, level of investment, scale of actions, and the lifespan of the NBS (Figure 14).

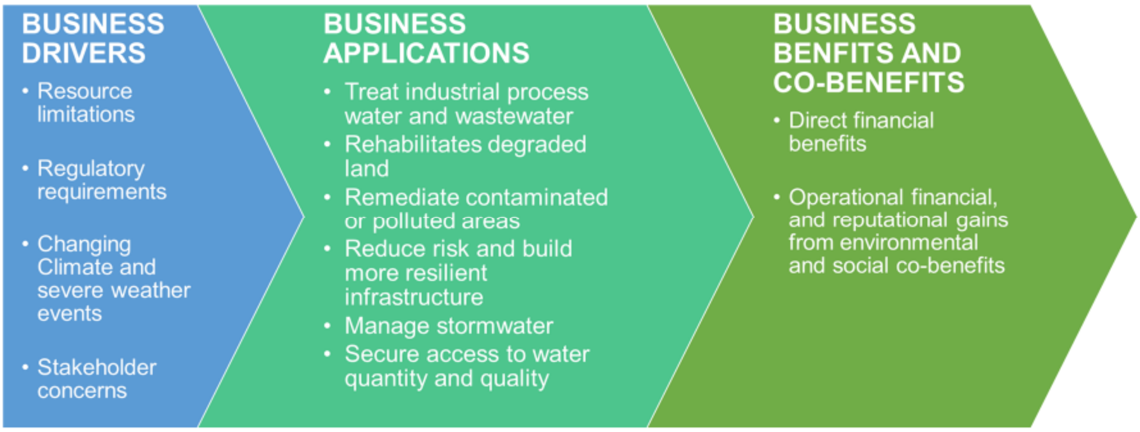


Figure 13. Example categories of drivers, applications, benefits and co-benefits of NIS-NBS (source WBCSD 2015).

Performance indicators and service measures associated with a NBS will vary with time and scale leading to shifts in the level of resilience, and therefore risk mitigation over time. This can be either an improvement or deterioration in performance during the project lifecycle. Existing roadmaps, which assume there is only one decision maker with control over a whole system, might overstate how effective proposed actions could be (Roelich and Giesekam 2018). The level of acceptable risk will be modified by the level of return on investment, which is often difficult to discern for NBS, with significant benefits often not quantified, monetized or not included in the business case or risk-return performance analysis. As such, we recognise that decision making within a framework underscored by deep uncertainty in performance indicators, investment returns or resilience capabilities requires further support around the motivations for undertaking particular NBS projects.

Capitalizing on the project benefits or defining the uncertainty, enabling the spread of the risk associated with investment can increase the implementation and effectiveness of NBS.IN the main, it has been recognised that value created from NBS which provide marketable products that can be privately appropriated, such as urban agriculture, are more readily privately financed and delivered through standard business models, rather than NBS, such as urban forests for example, which deliver nature-based value with mostly public good outcomes (e.g. improved air quality, CO2 abatement) (Toxopeus and Polzin 2017). One approach to solving the issue around value, benefit and return is to use blended financing, which secures a combination of a return in-kind, return in impact or return in financial terms.

Defining the NBS business case is thus often problematic. However, we believe, there remains an opportunity to create a structure, model or framework in which these co-benefits and multifunctional activities are identified, captured, realized or understood. Many analysts use the terms “framework,” “theory,” and “model” almost interchangeably, but we make a more precise distinction among these terms, as articulated by Ostrom (2005). Frameworks organize diagnostic, descriptive, and prescriptive inquiry (McGinnis and Ostrom 2014). Thus, we deploy an analytical framework to provide the basic vocabulary, and range of concepts that may be used to construct an NBS business case, with a focus not only on financial business returns, but also one that is fully inclusive of benefits or co-beneficiaries. Based on the literature and (see Chapter 1) case study evaluations the following framework has been devised. Based on the key elements of a hierarchy of steps/framework has been developed. This involves a two-step NBS project initiation phases namely SITE4 NBS evaluation frameworks that is followed by a more detailed analysis using the RISE4NBS concept (Figures 14 & 15). Valuing nature and the contributions it makes to climate change adaptation, resilience or mitigation requires the re-designing of classical business models to create fit for purpose nature-based solutions that will mobilize finance for sustainability investment providing pathways for direct action that allows for the inclusion of indirect co-benefits.

Creating this framework provides a workspace to allow for the development of a number of facilitation mechanism such as understanding scale and integration of diverse elements that may fall outside individual projects, strategies for long-term maintenance of NBS, the engagement of alternate stakeholders and co-beneficiaries and promote the inclusion of recognised standards for NBS. In promoting these tools, it is also recognised that strong advocacy is often required, typically thorough a dedicated coordinator that will act as a facilitator between interested parties or who provide opportunities to engage a wider stakeholder group.

This multi-scale temporal functionality and evaluation can be incorporated into a simple very high-level process matrix that provides a preliminary framework for any particular project. By starting with the very broad strategic view, the co-planning, niche innovations and other stakeholders can be identified. These elements are in part derived from Raymond et al (2017) and acts as an enabling framework for proponents and communities to build their projects and identify knowledge, skills, policy and financial gaps and developing natural capital accounts, using key performance indicators, while also collecting data and providing performance feedback loops. Through a first high-level evaluation using SITEs4NBS. This feeds into the next phase of operations that refines the elements of the NBS Business Case through the RISE4NBS framework that will evolve into the NBS Business Model Canvas, which may cover one or multiple projects.

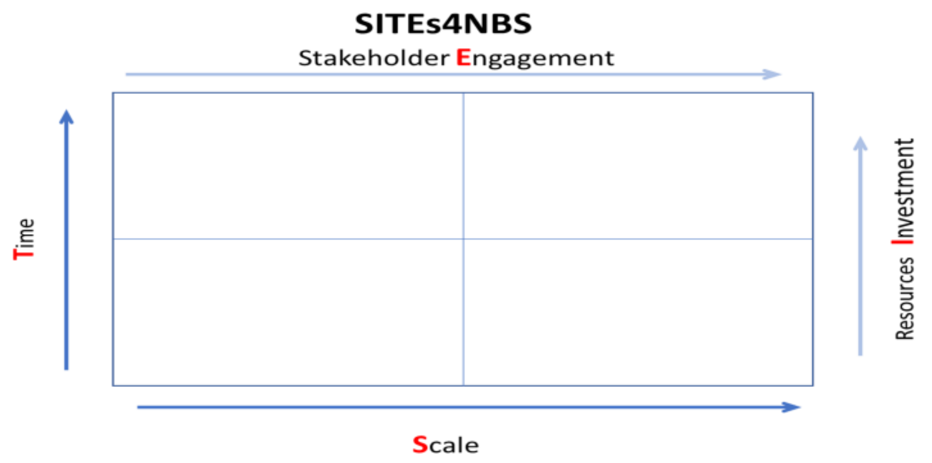


*Figure 14. The **SITE4NBS** analytical framework that conceptually identifies - a) **S**cale of project; b) Type of **I**nvestment; **T**ime required; and level of stakeholder **E**ngagement.*

RISE4NBS utilises the SITE4NBS high-level framework to plan the strategic engagement and NBS project design that includes the identified potential stakeholders, resource and financial options. These are linked with the maintenance, monitoring and co-benefits that accrue over time through the stages of the project(s), including: a) Design NBS implementation processes; b). Implement NBS; c). Potential transfer and upscale NBS (financial opportunity); and d). Monitor and evaluate co-benefits across all stages (and collect data on performance).

This approach provides the opportunity to evaluate each segment of the proposed project for both internal and external partners, beneficiaries, resource providers and determine the potential for staged or phased approaches to investment and implementation. Targets organisations and schemes and is scale dependent based on size of the project as outlined in Table 6. The high-level matrix SITE4NBS framework (or strategic case) feeds into the second integrative evaluation framework RISE4NBS which uses integrating tools such as Risk Analysis, Investment Focus, Stakeholders - Beneficiaries and Environmental-Socio-economic co—benefits, amongst others.

Table 6. Elements to be considered assessed under the SITEs4NBS & RISE4NBS process & analytical frameworks.

Level of Actions or Activities	Stakeholder and Community Engagement	Financial Investment or Resources Requirement	Time required to deliver Solutions (single or multiple)	Variability on the scale of the project
Individual to groups	Individuals Small action groups Small business	Voluntary in-kind Local fund raising Business - community support (local ownership schemes) crowdsourcing	Short • Days • Weeks • Months	Square metres (Wall/Roof) Hectares (open space, gardens, drainage)
Local Community	Local business Local action groups Communities Charities	Local council & municipal grants (local green spaces, local flood management) Crowdsourcing	Short • Weeks • Months • Years	Hectares (green space, parks) Square kilometres (woodlands, wetlands, flood management schemes)
Regional	Cities (C40, ICLEI, R100) Counties, District Councils; Companies; Regional and National Governments Charities NGOs	Regional grant schemes (Charities, regional flood management schemes National grants schemes (governments, entrepreneurs metropolitan investment bonds,)	Medium • Months • 1-3 years • 3-5 years • >5 years	Stream-River Catchments (wetlands, bogs, peatlands, leaky dams, water storages, flood and drought management schemes, resilience planning, national parks and open spaces).
Global	Cities (C40, ICLEI, R100) National Governments States Corporations NGOs	Global investment options (Green Bonds, blended finance, impact finance, Debt based finance)	Long • 5-10 years • 10-20 years • 20-50 years • >50	Actions on Climate change. (Mitigation and adaptation through national initiatives). SDGs (Supporting, linking, delivering)

We suggest using the RISE4NBS strategic framework and business case modelling (Figure 16) to assess the elements of the NBS project, including the following:

a. **R**esearch the **R**isk, and assess **R**egulations and Policy settings
- Variable Performance assessment over time-includes change in risk, returns and resilience
- Risk Analysis-including long term maintenance and returns
- Policy and Regulatory settings
- Governance requirements
- NBS standards or Performance Indicators

b. **I**nvestigate the **I**nvestment options
- Voluntary, in-kind contributions
- Impact & blended financing
- local ownership schemes
- Charities-NGOs
- Government scheme (H2020, Innovate UK, EPA, DEFRA)
- Metropolitan investment bonds
- Entrepreneurs
- Green Bonds
- Crowdsourcing

c. **S**takeholders contribution and Beneficiaries
- Communities
- Local government
- NGOs (WWF, IUCN, Woodlands Society)
- National companies
- Regional government
- National Government (
- Global Corporates

d. **E**valuate Socio-economic and **E**nvironmental Impacts (Multi-functionality)
- Economic appraisals (ROI, BCA, NPV, future projections, discount rates)
- Variable rates of return -investment and beneficiaries
- On-ground activities and linkages
- Real options costings - planning over variable timeframes and operational performance
- Market value and market-based instruments
- Avoided costs
- Public goods

How can this be applied? Figure 16 provides an illustration for an imagined base case for a project using the NBS evaluation framework to identify key elements that contribute to the four SITE4NBS elements (Scale, Investment, Time, Engagement) distributed evenly across the all phases. At each level we see an increase in complexity as each of the element are identified, quantified or described. By adopting this approach, we are able to see the potential implementation phases of a project shown here, prior to their implementation (see Figure 17 a,b).

Figure 15. Evaluating the integrative elements of the strategic business case for NBS using the RISE4NBS strategic framework and conceptual NBS business case.

By utilising the high-level matrix or evaluation framework we can arrive at the pre-implementation phase with a knowledge of the scale, timeframe, cost, identified beneficiaries & stakeholders, funding gaps, investor options for potential phases, and can then apply it to the Business Model Canvases to determine the fundamentals of the financing, implementation, investor interest and defining the value proposition (Table 7).

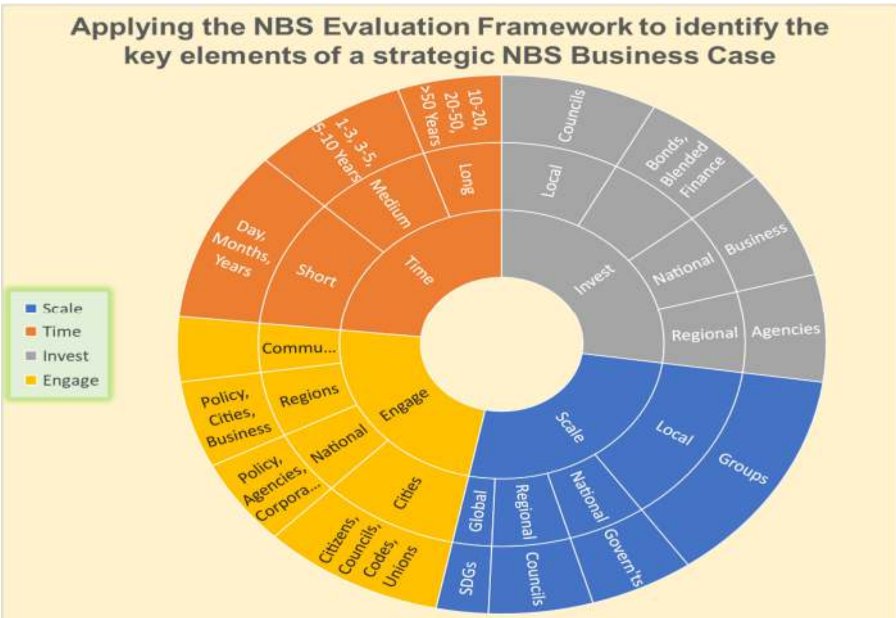
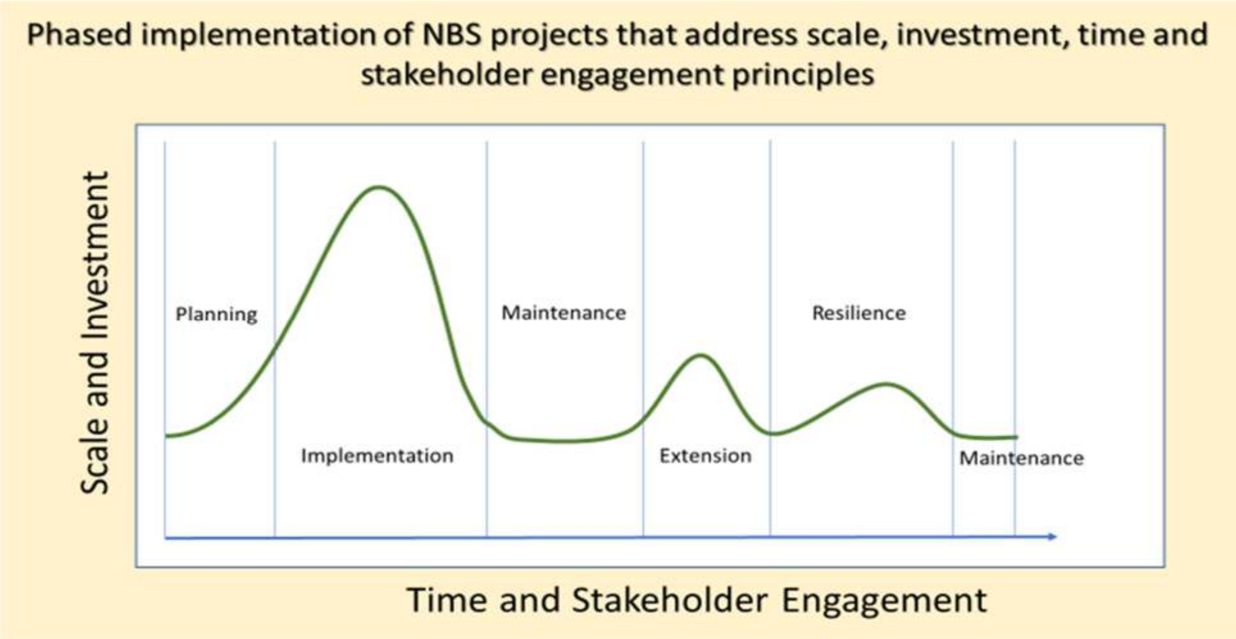
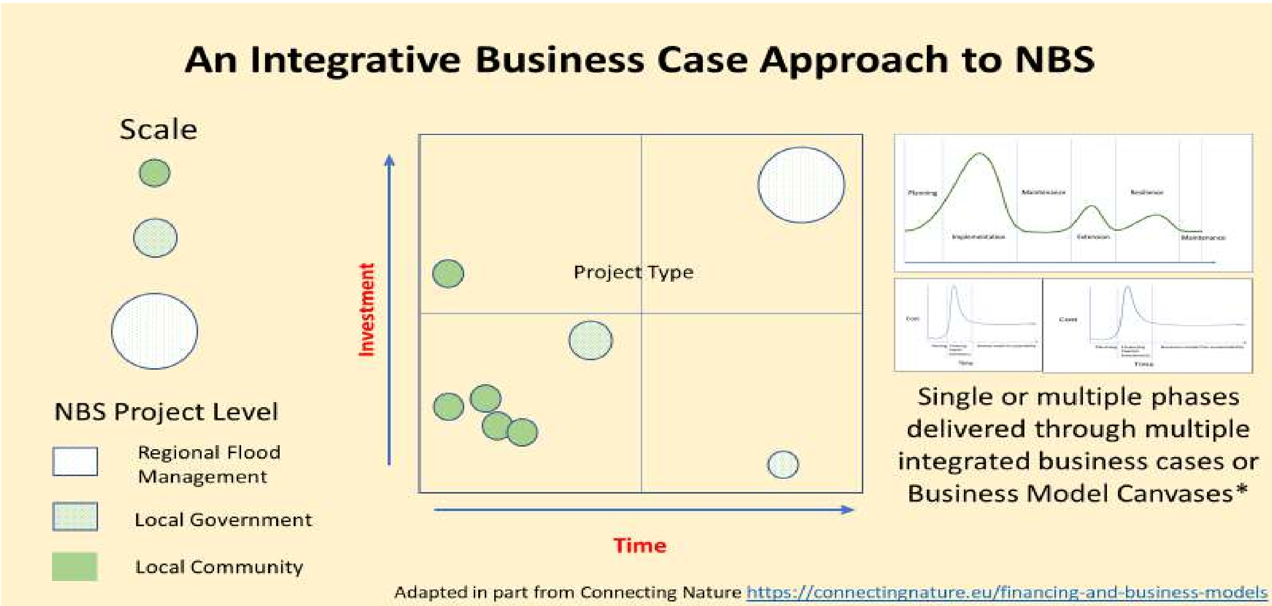


Figure 16. Application of the SITE4NBS analytical framework showing the breakdown and increase in complexity with Scale, Investment, Time and Engagement options.



a)



b)

Figure 17 a) Illustrates the potential multi-phase elements of a NIS-NBS project and how each phase can be broken down. b) Illustrates how these may be reconciled into different business model canvases for each phase thus providing a strategic framework for engagement of potential stakeholders, investors, beneficiaries and time scales.

By working through the BMC each element of the project is defined and the full potential of the project can be identified. Additionally the nine elements of the model are identified, described and costs including the Key Stakeholders, Activities and Resources, the potential Benefits Delivered and Beneficiaries are identified, the Value Proposition, Cost and Revenue Streams are defined, and the inclusion of Other Stakeholders that may be impacted or co-beneficiaries are listed.

Table 7. Some of the key elements, and example questions to be considered when defining the NBS Business model Canvas for a project proposal, based on the project elements identified using the SITES4NBS and RISE4NBS analytical frameworks.

<table>
<tr><th colspan="5">PROJECT DESCRIPTION: NBS Business Model Canvas Template</th></tr>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Proposition</th><th>Other Stakeholders</th><th>Beneficiaries</th></tr>
<tr>
<td rowspan="3">Who are the key investors?
Who are the key beneficiaries?
Who are key stakeholders?
Who are the key contributors</td>
<td>What are key activities of the Project?
How is the value in the project delivered/distributed?
Have you identified Key Revenue potential?
What is the timeline for project delivery?
Are key activites linked or co-dependent for delivery?</td>
<td>What is the projects' value proposition?
How is value delivered by the project?
What services can be delivered?
Are there co-benefits?
What are the critical needs to be delivered?</td>
<td>Are there any co-beneficiaries?
Can they be direct/indirect investors or stakeholders?
Can they add value?
Is the project stand-alone or can it contribute to other activities/actions?
Do the stakeholders change during the life-cycle of the project?</td>
<td>Can you identify beneficiaries of the project?
Are they external to the project?
Do they add value?
Do beneficiaries change during the life of the project?</td>
</tr>
<tr><th colspan="2">Key Resources/Investors</th><th colspan="2">Benefits Delivered</th></tr>
<tr>
<td colspan="2">What are the key resources needed to deliver the value proposition for the project?
How are the benefits delivered?
At what scale can the project be dleivered?
What are the key stakeholder relationships?
Does the timeline attract/detract or change investment opportunities?</td>
<td colspan="2">How are the benefits derived?
How are they delivered?
How cost-effective are the services delivered?
How efficiently are the services delivered?
Do the benefits change over time?</td>
</tr>
<tr><th colspan="2">Cost Structure</th><th colspan="3">Potential Revenue Streams</th></tr>
<tr>
<td colspan="2">What are the key Items to be purchased?
What are the costs of key activities to be undertaken?
What are key elements on the basis of cost, co-dependence and/or co-benefit?
Are there synergies with other projects that could be contributors?</td>
<td colspan="3">For what value are beneficiaries or stakeholders will to pay?
How much are they willing to pay for the services or infrastructure?
What revenue is generated by the project and by what financial instrument or revenue stream?
Are there non-monetised or in-tangible benefits that create value or need to be captured?</td>
</tr>
</table>

Using the proposed NBS-BMC template enables group discussion, planning and inclusion of both the direct and indirect actors that may be involved in the project. This can lead to the addition of other potential co-contributors that can be involved in obtaining finance, managing the short or long term aspects, ensuring that the wider benefits are defined and delivered, and that any dis-benefits (or dis-services) are identified and managed. In many cases the full lifecycle cost of a NBS is less than or equivalent to the traditional alternative, but there may be a higher initial outlay, or broader additional co-benefits associated with the NBS.

2.4. Applying the framework-Case Study Example

Hybrid (Grey-Green-Blue) Infrastructure solutions are designed and implemented to combine the unique strengths of each type of GGB infrastructure, providing additional benefits to society and nature as well as contributing to the de-risking of infrastructure systems and increasing resilience against shocks and stresses (Jurik et al. 2019). We apply the SITE4NBS framework to one case study example that looks at Natural Infrastructure or HGGB infrastructure that deploys NBS as part of the infrastructure solution to real world problems in the transport and water management sectors.[27]

Case Study Example: Green Tram Tracks in the Basler Transport Operator Network

A publicly owned construction company Basler Verkehrsbetribe(BVB) the Basler Transport Operator, in the public transport sector is considering installation of green tramlines in some sections of the city of Basel network.. The Installation of grass tramline would protect the tram infrastructure from climate change-related impacts (e.g. increased heat, flooding) and expand green spaces in the city to create a healthier and more socially acceptable environment.

- **Economic co-benefits**

Three options are evaluated: Asphalt, grass (or green NBS) or gravel ballast. Installation of green tramlines is cheaper than asphalt but more expensive than gravel. However, green tramlines can effectively mitigate overheating of tramlines on hot summer days and hence mitigate operational risks such as the distortion of tramline infrastructure. Such damage would be very costly for the owner of the infrastructure and the replacement work could affect the traffic in a city and have some negative consequences on the economy (delays, longer travel time, etc). In the case of separates lanes, there are mainly two types of track superstructure, ballasted track (track supported by crushed stone) and lawn track (track with grass and soil filling the space around and between tracks).

In comparison to ballasted tracks, lawn tracks are estimated to be 30-40 % more expensive over their entire service life (total construction and maintenance costs). Nevertheless, there are economic advantages to using a lawn track. For example, the noise-reducing properties of the lawn make any further noise protection measures superfluous. In addition, the tracks serve to improve the visual amenity of the areas in which they are used. This, together with the decreased noise, improves public acceptance of the tram infrastructure by local populations. This example from the Hybrid Infrastructure Handbook (Jurik et al 2019) also identified the following co-benefits.

- **Social co-benefits**

The lawn track enhances the value of the track area and thus contributes to a modern and city-friendly public transport system. In addition, the population's acceptance of new lane construction is higher, because the lawn track is more attractive. Urban greenery is an important positive location factor, as it contributes to

[27] These examples are extracted from the Case Study Hybrid Infrastructure Handbook (*In Press- 2019*)

the positive image of the city. However, as the amenity of the area is improved, this can also cause perverse impacts such as increased housing price which can have a negative impact on lower socioeconomic groups. Strategic analysis of the project from a SITE4NBS perspective is given in Table 9.

Table 8. Summary of the SITE4NBS high-level strategic analysis identifying some key elements for the RISE4NBS framework

Scale	Investors	Time Frame	Engagement
Local-City	Business	1-2 years	Affected Businesses
			Potential Investors
Local-City	Canton of Basel-Stadt	5 years	City Councils
			Local Communities
Local-City	Basler Verkehrsbetribe - Basler Transport Operator (BVB) - Planning	1-2 years	Building by BVB
			Government
Local-City	BVB Building	5 years	Tram Operator
			Local Communities
			Affected Small Businesses
Regional	BVB Operating - Maintaining	50 years	Tram Operator
			Local Communities
			Canton of Basel-Stadt

A more in-depth assessment demonstrates that for the grass tramlines there are substantial additional investment benefits, stakeholders and co-beneficiaries to consider with some of the natural benefits listed in Table 9. The other benefits include, but are not limited to:

- ***Commercial benefit***
  - mitigation of heat related (operational) risks
  - Reduce flood risk by improving drainage (Asphalt vs grass tramways)
  - Creation of jobs in maintenance (Tramlines are expected to have 50-year life span) & construction
  - Funded by the city council using Public funds
  - Improved property values near green tramlines
- ***Co-benefits***
  - Reduced heat island effect in a city
  - More visually appealing environment
  - Contribution to a city sustainability strategy
  - Improved quality of life for resident, business owners and public transport users
  - Reduce pollution through entrapment.

These elements are illustrated in RISE4NBS framing in Figure 18.

Table 9. Summary of the Natural Benefits of the of the Project* (Jurik et al 2019*)

Co-Benefits	Descriptions
Provides environmental co-benefits	The lawn increases rainwater retention; provides an insulating and cooling effect (through evapotranspiration); reduces the heat island effect in the inner city area; and acts as a pollutant binder.
Provides social co-benefits	Noise reduction in individual cases by up to 3 dB(A) compared to gravel tracks, resulting in higher population acceptance; increased quality of life and a healthier environment.
Risk mitigation potential	Medium (reduces the risks related to the track infrastructure). The lawn has an insulating and cooling effect for the tracks, giving protection from direct sunlight and heat, which can result in distortion of the tracks in extreme cases.
Climate change adaptation potential	High (reducing heat island effect and flash flood cloudburst, increasing the thermal tolerance of the tracks during heat wave events).

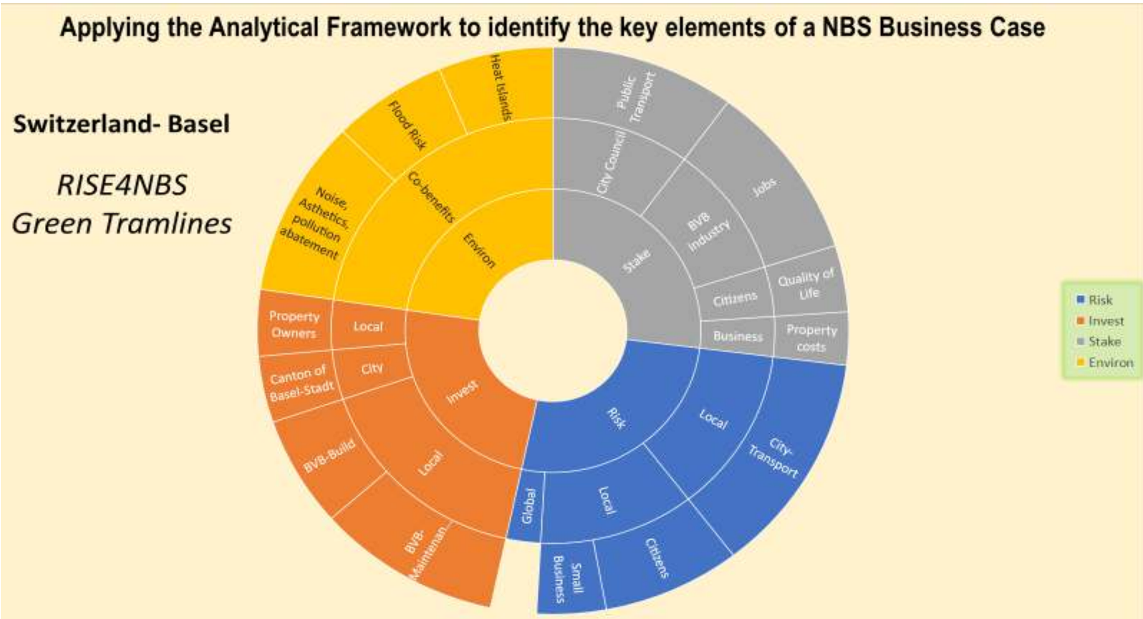


Figure 18. This diagram illustrates the potential for applying the four RISE4NBS elements to the Basel green tramlines business case in which category distributions are proportional for demonstration purposes.

2.5. Applying CBA to NBS

In the following section we examine how a CBA can be applied to nature based solutions providing some insights a to the approach, methodology, limitations and case studies associated with urban drainage, peatland restoration and natural flood management. The application of CBA requires estimated value of the benefits provided by NBS. Valuation means to assess how an intervention on an ecosystem (e.g. a NBS investment) enhances delivery of ES and what this means for people's well-being. This does not mean putting a price on nature but using a simple way of measuring changes in well-being associated with changes in the environment.

2.5.1. *Sustainable Urban Drainage Systems (SUDS) - Overview*

High urban densities and soil sealing has led to an increase in the risk of flooding in urban areas. Grey infrastructures such as piped drainage systems are "traditional" solutions to cope with excess rainwater in cities. However, existing drainage systems lack the capacity to cope with ever-increasing urbanisation and impacts of climate change, creating the requirement for complementary solutions. Sustainable urban drainage systems (SUDS) are considered as potential cost-effective alternatives to mitigate the risk of urban flooding, through slowing down and reducing the quantity of surface runoff delivered to an area, to minimize downstream flood risk and if designed appropriately reducing the risk of resultant diffuse pollution to urban water bodies. SUDS are also referred to as Stormwater Control Measures (SCM) or Water-Sensitive Urban Design (WSUD), all seek to "mimic" natural drainage regimes using source control, permeable paving, stormwater detention and increased infiltration, and evapotranspiration to mitigate flooding, improve water quality, and augment the value of recreational amenities and other ES. Thus, SUDS is a type of NBS that makes uses of a mix of natural processes and hybrid green-grey components to harvest, infiltrate, slow, store, convey and treat runoff. Examples of SUDS include rainwater harvesting systems, green roofs, permeable pavements, and trees. The choice of the type of SUDS depends largely on the state and characteristics of the drainage system in place and the components utilized.

- **Limitations to the uptake of SUDS**

Barriers to the uptake of SUDS include, similarly to the case of NFM discussed below, uncertainty about long-term maintenance, performance and (cost-)effectiveness. This is problematic since restricted implementation in turn prohibits generation of new evidence, which limits widening of uptake. Furthermore, the data and quantification measures that already exist are not widely known by potential stakeholders such as investors, and therefore not considered alongside traditional infrastructure. Another barrier to SUDS implementation resides in the fact that SUDS are both very site-specific and rapid-evolving technologies. This means that their associated costs and benefits and level of effectiveness vary greatly from case to case, and potentially over time. Additionally, current strategies and regulatory frameworks supporting implementation of SUDS are fragmented and inconsistent across the EU. The UK is one of the few countries having a legal framework on SUDS: *The National Planning Policy Framework* requires local authorities to include SUDS on new developments of 10 or more homes and all major new commercial and mixed use developments, unless it is demonstrated to be inappropriate. Yet, silo thinking is still a challenge: SUDS are often only considered as a possible approach when targeting surface water and flooding issues, despite their potential to also address water quality challenges and deliver wider benefits. Accounting for these co-benefits is necessary to strengthen the 'business case', and to stimulate, e.g. public-private partnerships that would combine blue/green spaces, human well-being, water management and climate change adaptation interests. Finally, SUDS implementation as with other NBS measures, faces challenges around ownership and maintenance responsibilities, which influences the cost-benefit results (Gordon-Walker et al. 2007).

- **Criteria for CBA**

Costs

SUDS can often cost less to both implement and maintain or monitor than underground piped systems. Comparative studies on the capital costs and benefits of traditional drainage and SUDS show that SUDS can offer cost savings that can range between 10% and 85% as compared to traditional drainage approaches (Woods Ballard et al. 2015).[28]

Benefits

In contrast with grey infrastructures, SUDS offer additional wider benefits besides providing water quality and water quantity management benefits. These co-benefits include, among others, improved public health, amenity services, enhanced biodiversity, and carbon sequestration. However, other NBS measures, benefits from SUDS are very site-specific. See Davis and Naumann (2017) for an overview of the potential range of benefits provided by SUDS.

- **Considerations for CBA application**

While a CBA of individual SUDS measures are continuously evaluated, comprehensive economic analyses of SUDS effect of different associated measures are still limited. For instance, green roofs and facade greening not only harvest rainfall and prevent runoff from directly entering sewer and drainage systems, but also decrease the energy consumption of buildings through better insulation, reduce the urban heat island effect in densely built areas, and add aesthetic value to buildings. Evaluation of the performance of such infrastructure needs to include quantification of these services. Incorporating the wider benefits at the neighbourhood level has demonstrated to result in even higher NPV of SUDS investment (Johnson and

[28] Note that these costs and benefits will vary across sites and installations

Geisendorf, 2019). Making informed decisions about drainage solutions necessitates a holistic approach, which implies that the costs and benefits associated with drainage implementation should be internalized as much as possible (Wolf et al. 2015).

Ossa-Moreno et al al. (2017) measured the economic performance of SUDS in the Decoy Brook catchment in London, UK. Through monetizing average annual benefits of SUDS in reducing surface flood risk and using a *value transfer approach*[29] to appraise its wider benefits, they found that including the latter improves the economic viability of SUDS substantially. They also show how to split the investment amongst multiple stakeholders, by highlighting the benefits each one derives.

2.5.2. *Peatland Restoration*

Conducting an economic analysis to understand if peatland restoration results in net social benefit to assess costs and benefits of peatland restoration over space and time, and how those are distributed across stakeholders. If the NPV of the peatland restoration scenario is positive, the restoration will generate welfare gains to society. Key criteria to the application of CBA[30] on peatland restoration and illustrations are described below.

- **Key criteria**

- *Private and societal benefits and costs*

Peatland restoration provides multiple benefits to society including carbon sequestration, water supply and regulation, habitat for wildlife, aesthetic values, and recreational services. Many of these benefits are difficult to value monetarily. Some of them benefit individuals directly (e.g. drinking water quality) while others deliver indirect benefits (e.g. regulating service such as nutrient cycling). Costs of peatland restoration include capital costs required for the implementation, on-going/management costs associated with the maintenance and monitoring of restoration sites and transaction costs, and opportunity costs. Capital and on-going costs vary greatly across restoration techniques (e.g. blocking grips, drains and gullies, re-profiling of peat) and depend mainly on the type of machinery, the scale of restoration, the accessibility of the area, and the degree of degradation. Opportunity costs, faced by the private land

[29] See description given later in document.

[30] Note that conducting a CBA is not always economically justified as it often implies (costly) data collection, modelling, and design.

manager, correspond to the income foregone from alternative land uses such as crop production. A precise understanding of these costs is hard as they largely vary across contexts.

> **Example :**Although there is currently little robust information on the cost of peatland restoration and that these figures are based on fragmented, and to some extent anecdotal evidence. Based on this sparse data the following cost estimates are provided**.** Capital cost estimates range from £200/ha to £10,000/ha and aggregate average annual on-going (or recurrent) cost estimates vary from £25/ha to £400/ha (Moxey and Moran 2014). Implementation and management costs vary from about £300 to £5,000/ha (Glenk & Martin-Ortega, 2018).[31]

- *Beneficiaries and affected stakeholders*

Peatland ES provide benefits across the population range from local inhabitants (e.g. recreational value), regional/catchment population (water quality benefits), to the global population (e.g. climate change mitigation from carbon storage).

- *Spatial and time scales*

Stocks and flows of ES generated by peatland restoration vary within space and over time. Some services like landscape beauty can be enjoyed on-site and others like drinking water quality are enjoyed off-site. Moreover, recovery of ES following restoration often happens on different time scales (different time paths of ES delivery), e.g. improvements to water quality might be visible in the short term while carbon storage take decades. Thus, the time required to achieve significant emissions reduction will vary from a few years in the case of weakly damaged peatlands, to several decades for heavily damaged areas. However, for the latter, realized potential emission savings will be higher.

- *Risk and uncertainty*

As an example of the importance of taking risk related to the delivery of ES outcomes into account, some land use interventions may for instance lead to turning peatlands into a net source of emissions. Similarly, there is a risk of peatland restoration resulting in enhanced peak flow events (in some catchments).

- **CBA Example 1: How much to invest in peatland restoration**

CBA is applied to calculate the maximum capital costs that can be invested in restoration so that it still generates net benefits to society, focusing on the carbon benefits only. The analysis includes estimated values of

[31] **Potential sources for costs and benefits:** (Moxey and Moran 2014). Peatland restoration: Some economic arithmetic; Glenk et al. 2017. The costs of peatland restoration in Scotland - considerations for data collection and systematic analysis; Okumah et al. 2019. How much does peatland restoration cost? Insights from the UK. Potential source of estimated benefits of peatland restoration: Ferré et al. 2019. A User Guide for Valuing the Benefits of Peatland Restoration.

carbon benefits from peatland restoration (at 280/ha/year, UK), and on-going costs of restoration that comprise of on-going management costs, monitoring costs, and opportunity costs (ranging from £25 to £400/ha/year, UK). These are used to compute the present value of the net carbon benefits, and how it varies for different on-going costs, time frames, and carbon prices (Figure 19). The present value of the net carbon benefits captures therefore the maximum (or break-even) capital cost that can be justified for restoration in different contexts.

The results show that if carbon differentials are high, capital costs are lower than the net present benefits of carbon, which are therefore sufficient to justify peatland restoration without considering other benefits and even if on-going and/or capital costs are also high. If the carbon differentials are very low, then on-going and/or capital costs also need to be low to justify restoration from an economic point of view. For low carbon differentials and/or low carbon prices and/or high on-going costs, non-carbon benefits will also need to be considered to justify this NBS.

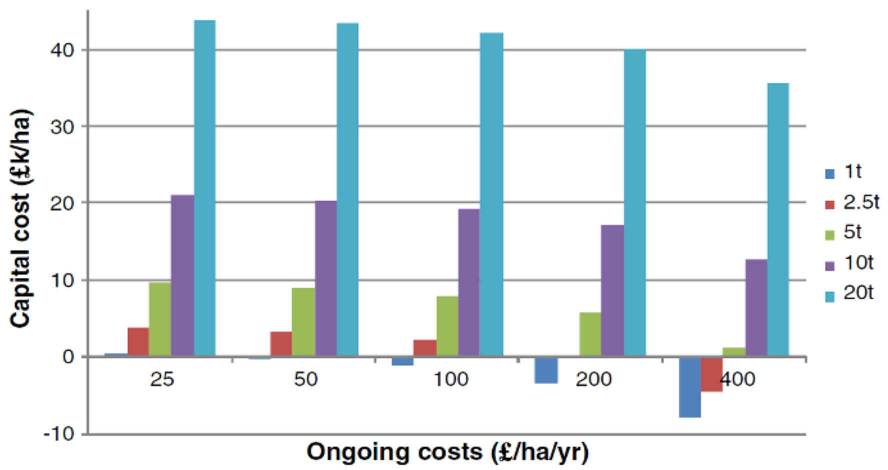


Figure 19. Maximum capital cost justified from carbon benefit values alone, by emission differentials and on-going costs for central C prices and for 40 years' time period. This maximum capital cost represents the breakeven point that can be justified for restoration (i.e. benefits would need to be at least as large as that to justify the capital expenditure).[32] Source: Moxey & Moran (2014).

- **CBA Example 2 : Identifying economically efficient restoration projects based on multiple benefits of peatland restoration**

A CBA is applied to understand whether investments in the restoration of degraded peatlands are economically efficient, i.e. whether they generate net benefits and to guide restoration decisions. The benefits of improved peatland condition in Scotland are compared with a range of varying capital and on-going

[32] Note: the value of carbon benefits is estimated based an emission differential of 5.0 tCO_2e/ha/year (it is the difference in the rate of CO_2e emissions between restored/healthy and degraded peatlands), and a central carbon price of £56/tC.

(recurrent) costs of restoration on a per hectare basis. The benefits consist of a bundle of benefits comprising of improved water quality, larger habitat for wildlife, and higher rate of carbon sequestration. They are estimated through a national level estimation of the non-market benefits of peatland restoration using environmental economic valuation techniques. Thus, NPV are estimated on a per hectare basis under varying capital and on-going costs for different combinations of peatland condition and spatial criteria, using an annual discount rate of 3.5% and a 25-year time period. The estimates NPV figures are captured into a "*space of Net Present Values*" (Figure 20) that provides a picture of the combinations of cost that yield an outcome that generates net benefits to society For example, for capital costs lower than 2500 £/ha and on-going costs lower than 300£/ha, an improvement of the peatland from poor to good condition, as defined in the study, generates positive net benefits (NPV > 0), which means that the restoration would be economically worthwhile. Thus, with a precise idea of costs, restoration managers can 'navigate' in the space and identify whether a particular restoration activity at a particular site makes economic sense and would generate welfare gains to society.[33] Although these costs are based on only the valuation of few a benefits, and a very fragmented database of cost information, as is he case with the NRM examples below.

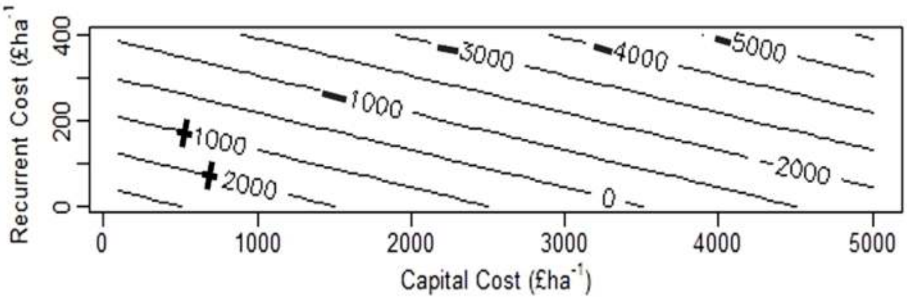


Figure 20. Net present values space: NPV in £/ha depending on baseline condition. Note values on the lower left side of the graph show positive NPV, while values on the upper right side of the graph show negative NPV. Source: Glenk & Martin-Ortega, 2018.

2.5.3. *Natural Flood Management*

An economic appraisal of NFM ('soft-engineering') is challenging, but the methodology is being adapted through applied projects. Moreover, the fact that many NFM measures have been implemented alongside more traditional forms of flood alleviation makes the assessment of the services delivered by NFM interventions difficult, making it is hard to disentangle the flooding mitigation benefits delivered by NFM

[33] Note: With better information on costs and spatial distribution of peatland, condition (e.g. related to GHG emissions, provision of other ES), the space can be updated and narrowed down to different locations, conditions, and restoration activities. The higher the level of detail, the more informed the investment into the NBS will be, the more targeted the restoration decisions will be, and the higher the efficiency of the resource allocation.

from the ones delivered by hard engineering flood defences (i.e. grey infrastructure). As mentioned above, the evidence surrounding the cost-efficiency of alternative NFM measures is limited and mainly based on modelling exercises supported by a small number of demonstration projects.

The section below focuses more particularly on afforestation as one type of NFM measure and focuses on trees developing a root system that creates preferential soil infiltration pathways for water flow and promoting higher infiltration rates. When combined with higher rates of rainfall interception, reduced erosion and increased evapotranspiration, results in reduced runoff and sediment generation. The influence of forests in the form of upstream or riparian woodland on flood flows can be measured empirically through monitoring of (sub)-catchments or through hydrological modelling assessments.

- **Key criteria**

- *Private and societal benefits and costs*

Outcomes of an NFM intervention depend on a wide range of factors, and therefore the extent to which NFM options are effective in managing flood risk in an area depends on the localised factors of each river catchment. Consequently, the type and magnitude of the benefits delivered by NFM vary with both the type of measure implemented and the location. NFM benefits can generally be distinguished into *direct* and *wider benefits*. **Direct** benefits comprise of reduced runoff (e.g. farm management to increase filtration) and flow attenuation (e.g. riparian tree planting, flood plain reconnection). Measuring flood risk reduction effectiveness requires data on the type and scale of the measure, hydrology of the area, soil types, and existing risk of flooding and expected degree of projected change in the future (e.g. 1 in 100 return period).[34] **Wider** benefits (co-benefits) of NFM include water quality improvement, carbon sequestration, habitat restoration, recreational opportunities, sediment yields reduction, phosphorus reduction, and nitrogen pesticides and pathogens reduction.

NFM may also deliver improved farm productivity and social benefits, through impact on well-being and aspirations. For instance, some NFM projects report that the engagement with the local community, and the creation of a partnership between the latter, local council, and the EA to constructively manage flood risk, as an important social benefit emerging from NFM. The local community was given a sense of

[34] Note that NFM measures are recognized to be more effective at reducing the frequency of flooding for high probability fluvial events (e.g. less than a one in twenty year return period) compared to extreme events (e.g. one in 200 year return period).

ownership of the NFM, which facilitates both further implementation of NFM and a shared understanding.

The costs of NFM include the costs of implementation (capital costs), on-going costs, and opportunity costs that can result from reduced agricultural production. Indirect costs or "dis-benefits" should also be considered and may include reduced water availability from increased tree cover that can reduce runoff generation, increase evapotranspiration and reduce soil moisture content. Maintaining water storage bodies at low levels before winter to accommodate higher winter rainfall may lead to water shortages in the subsequent year. In some cases, afforestation can also increase flood risk (e.g. woody debris and dams can be washed out). To limit costs, one way is to identify NFM measures that do not lead to a major opportunity cost at an individual farm-scale (e.g. involving less-productive land locations).

Furthermore, for many small communities, physical engineered measures, whose costs can be very large, are usually not viable due to limited public budgets. In these cases, NFM is a valuable contribution to reducing peak flows at a lower cost, in particular for smaller-scale flooding problems, and can be partially complemented by household flood protection measures. However, while some of these NFM measures may be much quicker to implement than approving and constructing larger grey infrastructure, some like planting riparian woodland take many years to be effective.

- **NFM benefit estimates**

In Defra (c2013): The value of the angling industry enhanced by NFM measures that improve riparian habitats was estimated at £80m/year, including 500 jobs, in an area of North East England. In the National Trust-owned Holnicote Estate, West Somerset, the annual benefits of woodland extension measure of 35haw were estimated as follows: flood control through avoided damage costs to flood risk properties: from £2,700 to £8,200 (using the assumption that additional woodland reduces flood probability by between 6 to 10% from current 1 in 100 years probability; drinking water benefit based on avoided costs in water treatment: from £700 to £3,500; climate mitigation benefits based on reduced GHG arising from carbon sequestration in wood growth: £10,100 to £30,300; and recreational benefits based on higher number of visitors in the area: from £0 to £ 4000, assuming 0 to 2,000 visits per year with each visit worth £2.20.

- *Spatial and time scales*

Changes in river fluxes, with regard to sediment, nutrients, induce changes in landscape morphology and ecology, which affects the risk of flooding. The planning of NBS should take these processes into account at various spatial scales. With regard to the time frame, it is often recommended that a long time frame be adopted to exploit the full potential of NBS, such as 20 to 50 years or longer.

- *Uncertainties and risk*

The uncertainty of climate change impacts on flood risk and should be accounted for with an appropriate range of probabilities and consequences. Hazard, exposure, and vulnerability are elements of risk to be considered in a CBA. In the case of computing a comparative CBA for NFM options vs. traditional measures, “exposure to optimism bias” also need to be accounted for. It reflects the number of unknown factors, which may be greater for NFM projects than for non-NBS scenarios.

Note that NFM is reported to be more cost effective in rural areas where the relative cost per person of infrastructure options would otherwise be high. In some cases, construction of a NFM scheme appear to be quicker and cheaper than traditional approaches involving hard engineering (hard flood defence), as long as the landowners are willing. Depending on the nature of the catchment and the level of flood risk, local solutions involving temporary natural storage upstream may be prioritized over traditionally engineered scheme for which expenditures cannot be justified.

NBS-CBA case study examples for NFM

Example 1. *In the Allan Water catchment – Scotland*, using modelling indicated that the NFM measures considered (e.g. riparian planting, realignment of channel, tree planting) would result in an actual benefit of 0.5% to 1.6% decrease in flood flows in the most downstream point of the catchment. A 16 to 27% reduction in flood flows could be achieved at a more local scale. The assessment considered four options for which annual damages from flooding were estimated at an average of £105,000/year. Damages avoided through different the NFM measures were estimated to vary from £972 to £2,574/year. Beside flooding benefits, additional social and environmental benefits were considered using a qualitative methodology. These results show that, on the basis of pure economics none of the considered NFM options present a compelling case for progression, with benefit-cost ratios of significantly less than unity. However, when all other factors including the wider benefits of NFM are considered, the viability of the considered projects is much stronger. (Defra 2013; see calculation details in Halcrow and CRESS 2011).

Example 2. *In Pickering – North Yorkshire (UK),* the present value of the costs associated with the measures were estimated at -£1,450,000 for agricultural production and forestry costs (mainly corresponding to the opportunity cost to the landowner owing to the change in land-use). Benefits include flood regulation, estimated at +£175,000 and co-benefits including habitat creation at +£2,733,000 and climate regulation at +£2,800,000. The study computed a NPV of up to 9.6 million (in 2011 prices). An indicative assessment of ecosystem benefits made for one measure in the project showed that habitat creation and climate regulation benefits were 32 times larger than the flood risk-reduction benefit (Defra, 2013). (Defra 2013; Defra 2015; Nisbet et al. 2011).

- **NBS-CBA Analysis on the net benefits of afforestation**

A CBA is applied to the impacts of afforestation on peak river flows under UKCP09 climate change projections in a rural catchment in Scotland. The study focuses on the effects of current and modelled afforestation as a NFM on Eddleston village (940 inhabitants). For this, a hydrological model simulates the transfer of water from rainfall to runoff through various stores, using rainfall intensities. Changes of flood peak are analysed under various management alternatives: i) currently 29 ha of planted riparian woodland in the floodplain, ii) three levels of hillslope broadleaf afforestation of the catchment relative to 19% wood cover in 2009 (30, 64 and 100% of afforestation corresponding to 2070, 4,416 and 6,900 ha respectively), and iii) a combination of the 100% hillslope broadleaf afforestation and the riparian woodland (Figure 21). The model assumes that 15% of the flood benefits are realised in year 1, and the benefits gradually increase until they are fully realised from year 15 onwards. Note that the lag times between implementation of NFM measure and consequent effects on runoff response are widely debated.

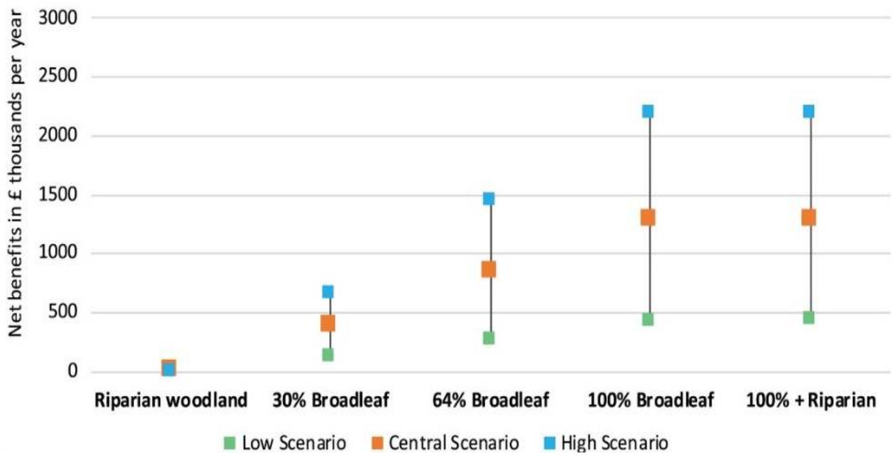


Figure 21. Range of net benefits under low, central and high scenarios across alternatives. Source: Dittrich. 2018. Note: NPVs across climate change scenarios are very similar since flood risk management is the only element that changes with the climate change scenarios. Flood risk constitutes a very low percentage of the overall benefits: ca. 1% across scenarios.

The CBA was conducted over 75 years with a discount rate of 3.5% until year 30, and 3% afterwards. Flood regulation monetary benefits are measured with the *avoided-cost method*,[35] which implied to classify all buildings at flood risk by type, and to estimate potential damages, in the presence vs absence of the NFM measures. Co-benefits of afforestation were valued using a *benefit transfer approach*.[36] Climate regulation, recreational and aesthetic values, water quality, as well as educational and biodiversity

[35] This method will be explained later in Chapter 2.
[36] See explanation given later in Chapter 2.

benefits were monetized. The CBA accounted for investment and maintenance costs (including opportunity costs) of the afforestation measure.

Highly significant positive NPV's are found for all alternatives when all monetised ES are considered: it ranges from £20,000 (central scenario) for the riparian woodland only, to £1,3 million/year (central scenario) for 100% afforestation combined with riparian woodland. While all alternatives are economically worthwhile when accounting for co-benefits (recreational and climate services especially), investment in riparian woodland delivers a positive NPV alone when considering flood regulation benefits only. For 2040 and 2080 flows, the analysis highlights the complementary role of NFM alongside hard engineered measures as part of a flood management strategy under climate change (Figure 22). The study reinforces the findings along which re-afforestation on hillslope and floodplain is a cost-effective mean for providing flood regulation, particularly when benefits other than flood regulation are included.

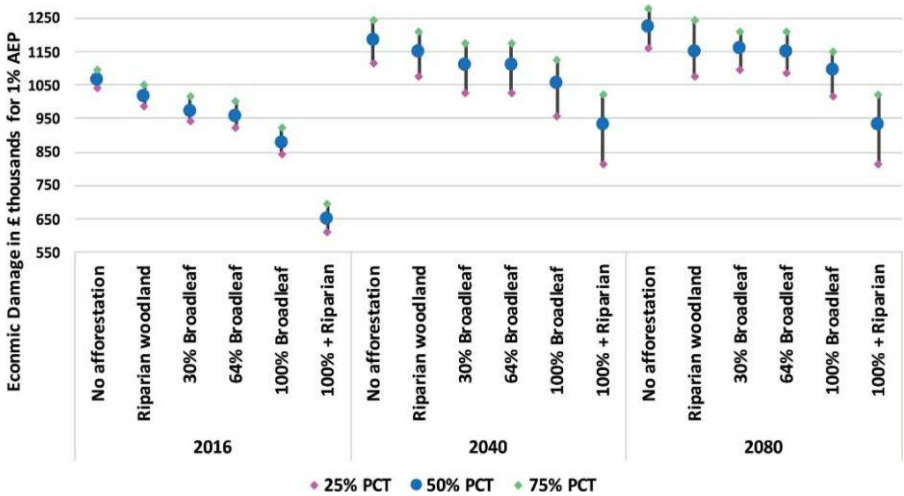


Figure 22. Benefits and costs in thousands (£) per year for the various alternatives by benefit category for the central scenario in 2016. Source: Dittrich et al. 2018. (AEP = annual exceedance probability).

2.6. Importance of NBS in promoting resilient and sustainable infrastructure

Climate change, population growth and resource security represent significant global challenges over the 4-5 decades, creating a demand for new and refurbished infrastructure while maintaining or improving the natural environment (Rozenberg and Fay 2019). Various reports have noted that while extensive infrastructure investment is required to meet these challenges, spending efficiency and effectively is key, and success will be dependent on the targeted deliverables and the policy framing that accompanies this investment. Furthermore, the investment focus should contexed with regard to the service gap, economic growth aspirations, and social and environmental objectives, rather than on the perceived investment gap. Improving services typically requires much more than just capital expenditure, and other project elements include life-cycle maintenance as a necessary condition for success (Rozenberg and Fay 2019).

2.6.1. Valuation of the benefits of NBS

Values for non-marketed benefits associated with NBS can be elicited through primary valuation, although not all values or benefits associated with NBS are easily captured through a monetary valuation, as they may be intrinsically in-tangible in nature. However, where performance measures can be collected there is an explicit need to monitor NBS, and for careful investigation of the process links from NBS implementation to ES responses, and how these responses evolve over time. This is suggestive of a complex intertwined process, and hence the need for monitoring and for furthering our understanding on how NBS (or ES) respond over time.. Below is an overview of existing valuations methods, including tips for applying them, and illustrations of valuation for the selected NBS. The values presented in the illustrations cannot serve as direct value estimates of other cases, since they are specific to the context in which they are estimated, e.g. they are dependent on the conditions of the ecosystem that are considered in the valuation. Yet, they can serve as illustrations, e.g. of order of magnitude, or as a reference point. Although estimates values of non-marketed benefits/costs are not transferrable from one case/site to another, they are useful to understand how these values can be calculated to increase the accuracy of the estimated economic performance indicators associated to the implementation of an NBS.

Note also that the estimated value of ES often represents a lower bound of its actual value: under-estimation of values is common for services delivered at large scales. If not stated otherwise, all the values are expressed as present values of the year of the study. To translate those values into present values, the economic inflation from the year of study to the present, need to be considered.

12.1.1 Valuation methods – Overview

The methods used to value the benefits from NBS to society use money as a simplified metric to value changes in human well-being, so that they can be compared with costs and used as part of economic decisions. These methods will always be limited by the fact that human well-being is more complex than any simplified single metric can ever capture. They are also criticised because, while they are not meant to set a price on ES, they can be used as an argument for the commodification of nature. The choice of the method will depend on the type of outcome/good or service to be valued, the type of values to be estimated (use values are estimated by all of the methods but non-use values can only be estimated by stated-preference methods), the purpose of the valuation, the availability of data, the required degree of accuracy of results (e.g. level of uncertainty surrounding the outcome differs significantly across methods), and resources and time available to undertake the valuation.

- **Valuing marketed services**

If the ES is marketed, it is possible to apply the market price approach or the production function approach. The ***market price approach*** consists of measuring what it costs to buy or sell a good or product. It estimates people's actual willingness-to-pay and therefore uses observed data of actual preferences. The major advantage of this technique is that it is relatively easy to apply, as it makes use of generally available information on prices. In the ***production function approach***, ES are modelled as inputs into the production of marketed goods and services, or as a joint output in production. This method implies a quantification of the biophysical relationship that links changes in supply or quality of ES with management options, which is not always easy. It also has substantial data requirements.

Cost-based valuation approach

Cost-based valuation methods rely on estimating the costs that would be incurred if the service were no longer provided. The ***avoided-cost method*** consists of measuring the costs that would have been incurred in the absence of the ES; it uses either the value of property or assets protected, or the cost of actions taken to avoid damages, as a measure of the benefits provided by an ecosystem. The ***mitigation (abatement) cost method*** consists of measuring the cost of mitigating the effects of loss of the ES (i.e. the adverse environmental impacts resulting from the absence of the service). One advantage of a cost-based approach is that it is easier to measure costs of producing benefits than to value the benefits themselves, especially when benefits are non-marketed. It does not necessitate a high level of resource and is also relatively simple to apply and analyse. It relies on secondary data on benefits from ES and the cost of alternatives. One disadvantage of this approach though, for the avoided-cost method in particular, is that very often estimates of damages remain hypothetical.

Other cost-based approaches rely on estimating the costs that would be incurred if the service provided by an ecosystem would have to be re-created. The value of an ES can be inferred by estimating how much it costs to replace (using artificial means) or restore it. Thus, the ***replacement cost method*** consists of estimating the costs incurred by replacing the ES with man-made technologies. It is based on the idea that an alternative artificial technology has to be found to provide the lost service (e.g. the value of a peatland acting as a natural reservoir can be estimated as the cost of constructing and operating an artificial reservoir of a similar capacity). The ***restoration cost method*** consists of measuring the cost of restoring the ES. One limitation of these approaches is the focus on the positive benefits of man-made alternatives, and the lack of consideration of potential negative externalities. It further assumes that the net benefits generated by expenditure on man-made alternatives match the original level of benefits from the ecosystem, which is not necessarily accurate.

- **Valuing non-marketed services**

Revealed preferences approach

The revealed preferences approach consists of capturing how people value non-marketed ES by observing the consumption pattern of goods and services with which they are associated and that do have a market. Thus, **the *travel cost method*** aims to derive the recreational value of a site, such as a national park, based on the travel time and costs people spent to visit the site. It captures people's implied willingness to pay (WTP) by understanding how much people spend to use ecosystems for recreational purposes. Data on site visits are used to derive a demand curve for recreational services, and to value, e.g. the beauty of an area. The main advantage of this method is that it draws on observed data. However, it requires statistical analysis and modelling, and large datasets related to recreational activities, travel costs, and site characteristics in order to construct information on visitor demand. Travel cost surveys are usually expensive and time consuming to carry out. In addition, the method provides the value of only one overall factor linked to recreation and it is difficult to disentangle the effects of, e.g. landscape beauty vs. water. The results are also sensitive to assumptions about cost of time.

The ***hedonic value approach*** focuses on estimating economic values of ES that directly affect the price of marketed goods using the idea that the price of a good is related to its (environmental) characteristics. Thus, correlations can be conducted to analyse the relationship between housing values and environmental features, and derive a willingness-to-pay for scenery/landscape. For instance, it could be possible to value the spiritual and cultural services of an area (e.g. restored peatland, or new forest) similarly to the price difference between a residence near such area and a similar property which isn't near such clear air, beautiful views, and iconic landscape.

Stated preference approach

For ES like biodiversity and wildlife, no associated market can be found. The only way to measure their values is to create hypothetical markets through surveys in which people are asked to state their WTP. Alternative scenarios representing various statuses or conditions of the ecosystem (e.g. various levels of peatland restoration) are presented to the respondent, who is asked how much (s)he would be willing to pay for the environmental improvement, as if they would be able to buy such improvement.

The contingent valuation method requires people to say how much they would be willing to pay for an ES, under the theoretical condition that, e.g. biodiversity could be bought. Through a survey, respondents are asked for their maximum WTP for a predetermined increase or decrease in the condition of an ecosystem or environmental quality. They can be asked either to state how much additional tax they are willing to pay to preserve a particular ES and avoid its degradation, or to state the amount of compensation they would be willing to accept to give up the ES. Questions either present a bid amount to respondents who state whether or not they are willing to pay/accept it, or simply ask respondents how much they are willing to pay or accept. The contingent valuation method is relatively easy to implement. Yet, it is best used for estimating the value of services that are easily identified and understood by users.

The choice experiment method, on the other hand, allows a valuation of various attributes including bundles of services. It therefore applies well to ecosystems that produce many services simultaneously. The method is based around the idea that a good can be described in terms of its attributes/characteristics, and it focuses on the value of a change in these attributes. Respondents need to select between a set of alternatives, and values are derived from the responses by including a money indicator as one of the attributes. Economic values are inferred by the trade-offs respondents make between different combinations of attributes and between monetary and non-monetary attributes. Choice experiments allow individuals to evaluate non-market benefits described in an intuitive and meaningful way. Note that the method requires complex data collection including large-scale surveys, and sophisticated statistical analysis and modelling.

The results of both stated-preference methods are highly sensitive to the design of choice scenarios and how the survey is conducted. One main disadvantage resides in the fact that responses to willingness-to-pay questions are hypothetical and may not reflect true behaviour. Yet, an important result obtained from these methods is the understanding of the order of magnitude of the willingness-to-pay (qualitative aspect). Hypothetical scenarios might also be misunderstood or found to be unconvincing to respondents, which can result in ‘protest votes’ (i.e. zero bids), hence the importance of carefully designing the survey in order to avoid or mitigate these biases.

Results are often dependent on the policy context described in the survey. Thus, the value of ES estimated in one context is not easily transferable to another case. Last, people’s WTP depends on a wide range of factors, e.g. socio-economic characteristics such as income, behavioural factors such as those associated with past experience or place of residence, and availability of substitutes. This result in heterogeneity in economic values of ES benefits. This can be partly mitigated by including these factors in the statistical analysis of stated preferences data, but there is a limit to how many of these factors can be included in the analysis.

Deliberative Monetary Valuation Method (DMV)

The **Deliberative Monetary Valuation (DMV) Method** is a 'hybrid' valuation method that incorporates deliberative processes into conventional stated preference methods. This typically entails a deliberative group process that involves discussion and learning and generates agreed group-based values (shared values) of the benefits of an ecosystem. The DMV method developed on the argument that a small group discussion can help with preference formation and inclusion of non-economic values. In DMV, participants explore the values that should guide their group decisions through a process of reasoned discourse. Debates can focus on what the benefits mean, which benefits are most important in the short vs. long-term, and who would benefit. The outcomes of DMV method depend on whether values are provided by individuals in a group setting, or by the group as shared expressions of value, and whether individual amounts are established that are akin to individual WTP, or whether participants establish a pre-aggregated amount. Because of its deliberative nature, DMV method is resource intensive and cannot be applied to very large populations.

Benefit (or value) transfer method

When it is not possible to estimate the value of a service or a management scenario at a given site, e.g. because of budget constraints, the '**benefit (or value) transfer'** method may be used. It is an indirect way of valuing ES that relies on 'borrowing' the values as estimated in a pre-existing valuation study, and transferring them to the site of interest. The values that are used need to be obtained at a site that is as similar as possible to the site that one is trying to establish a value for. Thus, WTP estimates from one site can be used as proxies for another site.

Given the limited resources that may be available for conducting valuation studies, value transfer can provide a fast and affordable process to estimate values for ES. Other advantages include the fact that value transfer can also be applied on a scale that would not be feasible for primary research in terms of valuing large numbers of sites. Methodologically, it also provides consistency in the estimation of values across sites to be valued. However, even if one identifies a very similar site, because benefits and beneficiaries are always site specific, the value transfer method always incurs 'transfer' errors. These errors may stem from measurement error in primary valuation estimates, transfer of the values between sites (if those differ in population or environmental/physical characteristics, e.g. quantity and/or quality of the service), or temporal effect: preferences and values for ES is often not constant over time. These errors can be very large thus, the method should only be applied if there are no other options.

2.6.2. *Valuing benefits of peatland restoration – Method, examples, and evidence*

- **Carbon benefits**

Carbon sequestration by peatlands means cost savings from not having to abate that carbon by other means. The benefits that peatlands produce in the form of carbon sequestration can then be measured using the abatement (or mitigation) cost method, which consists of appraising the economic value of estimated net carbon dioxide equivalents (CO_{2e}) savings from peatland restoration in a given year. Applying this method is possible because there exists a market price for carbon. The estimation consists of multiplying the estimated net CO_{2e} savings, i.e. the differential in emissions between a damaged site and a near-natural site or between a damaged site and a restored site, by the price of carbon in that year. The following data are required:

- *Market price of carbon*
- *For predicting carbon benefits on a site to be restored: a measure of on-site carbon and other greenhouse-gas emissions, and estimation of the potential differential that can be achieved after restoration*
- *For evaluating carbon benefits of restored sites: a measure of rates of carbon emissions and carbon sequestration on the restored site and an estimation of the differential (estimation of the GHG emissions before restoration)*

Estimating the differential implies to estimate carbon storage in peatlands, which is quantified based on the balance between carbon losses from the system through gaseous emissions, that is, carbon dioxide and methane, aquatic pathways (Dissolved and Particulate Organic Carbon respectively), as well as carbon accumulation processes related to vegetation. The estimated value of carbon benefits will depend on the accuracy of estimated measures of rates of emissions and sequestration of carbon for the studied area. Such measures are complex as they need to account for the losses of carbon to water and the increased presence of methane under wetter conditions, among other things.

> Example: In the UK, estimated benefits of carbon from restored peatland considering a differential of 5.0 tCO_{2e}/ha/year and a central carbon price of £13/tC (traded market price) is equal to £65/ha/year. For a carbon price at £56/tC (non-traded market price), it is equal to £280/ha/year. High carbon emission differentials are sufficient to justify peatlands restoration (without considering non-carbon benefits) even if recurrent and/or capital costs are also high. Note that different unit prices for carbon benefits could be used. Higher prices would increase the case for restoration and lower prices would reduce it (Moxey and Moran 2014).

- **Drinking water quality benefits**

Peatland's contribution to filtering and cleaning water in the uplands results in cost-savings from not having to treat that water through other means. Thus, the benefits that peatlands produce in the form of improved water quality in the catchment can be measured using the **avoided-cost method**, which consists of evaluating the economic value of water treatment costs savings from peatland restoration by calculating how much it would cost to treat that water with one of the existing treatment systems. The application of the method depends on the availability of data on reduced water treatment costs attributed to a change in the management of a peatland (i.e. over a long time period). This necessitates a good understanding of the different types of costs and investments that come into play.

Peatland restoration benefits water quality through reducing concentration of suspended sediments or fine particulate organic matter and reducing microbial breakdown of peat. This leads to decreased concentrations of colour in the water and reduces the amount of chemical dosing needed for treating the water. Removal of Dissolved Organic Carbon (DOC) is a key treatment process for the supply of drinkable water from peat-dominated catchments and it represents the largest cost to UK water utilities. Quantitative and monetary relationships between increased water quality and decreased treatment costs is hard due to the difficulty of disentangling other factors such as treatment costs associated with pesticides. Water utility companies' treatment variable/operational costs are partly determined by the need for a rapid response to a change in water quality. There might be minimal treatment if the water quality is good, but treatment costs may increase sharply and suddenly if the quality deteriorates, e.g. after heavy rainfall. Capital costs include investments in treatment infrastructure. Any reduction in capital costs implies an understanding of how a change in water quality affects infrastructure over time. Thus, savings in water treatment may only be significant when a treatment facility has to be replaced, enabling scale-back on capital requirements. Given that water colour is increasing at a national level due to a decline in acid rain, the gain from peatland restoration might also consist of stable treatment costs. Generally, the data needed to apply the method include:

- *Water quality indicator, before and after peatland restoration*
- *Cost of the various water treatment works, including fixed and variable costs, before and after restoration, from water utilities companies.*

Example:
In the Keighley Moor and Watersheddles catchments - Yorkshire – UK: the rates of DOC in water and therefore the quality of the drinkable water depends on land management and on rewetting interventions on the peatland. As compared to a status quo situation, a decline scenario characterised by a 30% increase in DOC generates a value of -£2,5 million in the catchment. An improve scenario with a 15% decrease in DOC implies that there are no capital costs associated to MIEX plants' DOC treatment of meeting drinking water standards and that operational costs are reduced; it generates a value of £2,2 million. These values are based on the assumption that catchments deliver 8 to 10 megalitres/day into the water treatment system. (Harlow et al. 2012)
In the Bamford catchment - West England/East Wales - UK, the costs that could be avoided in the presence of healthy peatlands, and therefore the value of water quality benefits provided by peatlands is estimated at £2000 to £4000/week (cost of removing peaty sediment from drinking water) and £160,000/year (2010 value) (cost of removing 11,500 tonnes of sediment to meet drinking water standards on particulates). This is based on the Severn Trent Water company, which is a water authority responsible for water management and supply, and for wastewater treatment and disposal. (EFTEC, 2015: Goodyer, 2016)

- **Wider ecological water quality benefits**

Water quality benefits provided by peatland that concern the achievement of a good water ecological status are not traded on the market. Survey-based methods such as a **contingent valuation method** are used to value these benefits, which means directly asking people for their willingness-to-pay for an improved ecological status of the water. This requires an understanding of:

- *Downstream water bodies that will benefit from increased water quality through peatland restoration upstream., Note that improvements of peatland-induced water quality vary across space since water quality responds differently to restoration across location*
- *The services provided by the increased water quality*
- *The population that benefits from the increased water quality, and how.*

Example:

In the Ouse catchment - North Humber basin – UK, river water quality environmental improvement is valued at £21/individual/year based on the average willingness-to-pay for different degrees of water quality improvement. The further away a respondent lives from the site, the lower the willingness-to-pay and the closer the respondent lives to another site (river or coast), the less (s)he is willing to pay for the site under valuation. (Bateman et al. 2008)

In the River Tame – Trent, UK, the willingness-to-pay for River Tame water quality improvements is equal to £9.60/household/year for a small improvement, £15.34/household/year for a medium improvement and £22.89/household/year for a large improvement, excluding zero bids. (Bateman et al. 2006).

- **Recreational services**

The benefits that peatlands produce in the form of recreation and amenities**,** which are not traded on the market, can be measured using the **contingent valuation method**. This means asking people for their willingness-to-pay for an increased level of recreational benefits delivery. Necessary data include:

- *Map of the area including the features that contribute to the ecosystem being used for recreational purposes and recreational activities*
- *Information on whether individuals have visited the site previously (in order to distinguish use and non-use values). Data sources: Representative sample of the population (to collect information on socio-economic characteristics of the respondents*

Example:

In Scottish 'Flow' Country – UK, the value of the benefits of the recreational services provided by the wetland is estimated at £327/ha. This is based on the calculation of the mean willingness-to-pay of regional residents for conserving the area (£16.79/household) and on an extrapolation of the average willingness-to-pay over the entire regional population. (Barbier et al. 1997). **In Ireland,** the value of cultural services that peatlands provide to the public is estimated at £51/person/year, which is the average willingness-to-pay of people for a national peatland protection policy. (Barbier et al. 1997)

Recreational benefits of peatlands can also be valued using a **travel cost method**, which is based on the observation such services can only be realised through physical access to nature. This implies that individuals seeking to enjoy the service will need to spend time and money to travel to the site. The method assumes that people value recreation at that site, at least as much as how much it costs them to get there. Thus, the recreational value equals the costs of reaching the area. Data required for include: a) Direct expenditure by visitors: spending on fees, travel, food, and accommodation (minimum value a visitor places on a site for recreation), b) Time spent to travel and visit the site, iii) Amount that visitors would be prepared to pay for a visit. Data sources: Population/individuals.

Example: **In the UK**, consumer surplus values per trip for a 10% change in river attributes influencing recreational benefits (i.e. flow rates, biological quality, nutrient pollution level) range from £0.04 to £3.93 depending on the attribute. (Johnstone and Markandya, 2006).

- **Bundles of ecosystem services associated with peatland condition**

Peatlands provide many overlapping services simultaneously. If one is interested in the overall value of these services, it is not possible to simply sum up the value estimated for each of them individually, as this would risk double counting. Instead, the services need to be considered as a bundle and their joint value need to be estimated, e.g. using **the choice experiment method**, in which the valued attributes are explicitly defined as bundle of services.

Example: The average monetary value that Scottish people attach to the benefits associated with peatland restoration in terms of carbon storage, water quality and wildlife habitat ranges from £127 to £414/ha/year, depending on the degree of improvement and location of restoration. Note the these only represent a proportion of the benefits, i.e. those that benefit the Scottish population.

2.6.3. Valuing benefits of Natural Flood Management - Method, examples, and evidence

This section presents examples of the valuation of the benefits provided by NFM interventions, including flood risk mitigation and wider ecological benefits, such as cultural and recreational services provided by water bodies. Tangible impacts of flooding on households (direct benefit of NFM) are relatively easy to estimate in monetary terms and include the cost of reinstating or replacing damaged items. Intangible impacts and co-benefits, which are harder to value, include, among other, the loss of irreplaceable items or items of sentimental value, health impacts and psychological effects of flooding (e.g. anxiety about relocation).

- **Flood protection benefits**

Reducing flood risks may be achieved through the restoration of wetland areas located upland in the catchment, through the creation of water storage areas. These benefits might be measured using the **avoided-cost method,** i.e. by estimating the costs that are saved by preventing flood damages. Flood damages mainly include damages to agricultural crops (loss in harvest, soil degradation), buildings (decline in property values), and businesses. The method requires data on:

- *Area at risk of flooding*
- *Flood risks (e.g. X in a 100 year time flood)*
- *Property values, and crop production and value*
- *Businesses within the risk area including their value*
- *Number and value of insurance claims*

Examples: **In Cambridgeshire – Wicken Fen National Nature Reserve – UK,** the flood protection benefits to farmers and homeowners from restoring the wetland - equivalent to avoided damage to crops and property - is estimated at £17,750/year or £37/ha/year. This is based on the fact that the restored wetland has the capacity to protect 2000ha of farmland and 10 homes by acting as a flood storage area. The value is calculated using crop values, the cost to homeowners using the Environment Agency' estimates of damage cost of a flooded home and insurance claims associated with past flood events – based on a risk of flooding of the area of once every 20 years. (Peh et al. 2014)

In Calderdale and Upper Calder Valley - West Yorkshire – UK, the estimated value of flooding mitigation through peatland restoration is £47 million, which represents the losses generated by the flooding event of Boxing Day 2015 to the local economy – calculation based on the damages/costs to 1600 small and medium sized businesses. It assumes an average loss per firm of £47,000 and that for every £1 reported in direct losses another £0.6 on average was lost indirectly throughout the regional economy. (Saka et al. 2016)

- **Health benefits (co-benefits)**

Wetland contribution to upland water storage results in a lower likelihood of flooding downstream, leading to fewer negative impacts on human health, such lower level of psychological stress. Value of health impacts and psychological effects of flooding, including anxiety about the need to be relocated are difficult to obtain. A **contingent valuation method** can be used to investigate the maximum willingness-to-pay of floodplain residents to avoid or reduce the identified intangible impacts of flooding, as a measure of their welfare gains associated with reducing this risk.

Example:

In the UK, the value of flooding mitigation benefits on health of people at risk of being affected by flooding is estimated at £653/household/year, which is the average willingness-to-pay per household to avoid or reduce psychological impacts from flooding by investing in Property Level Flood Risk Adaptation measures, based on the 2007's flood. (Joseph et al. 2015)

- **Recreational benefits (co-benefits)**

The benefits that NFM interventions produce in the form of recreation and amenities, which are not traded on the market, can be measured using the **contingent valuation method**. Data required for applying the contingent valuation method to recreational services include:

- Map of the area including the features that contribute to the ecosystem being used for recreational purposes and recreational activities
- Information on whether individuals have visited the site previously (in order to distinguish use and non-use values).
- Information on socio-economic characteristics of the respondents.

Example: **In Norfolk Broads - East Anglia – UK,** the recreational and amenity use value estimates of the wetland is estimated at £94/household, which is the mean willingness-to-pay to conserve the recreational benefits of the wetland area. Moreover, the non-use values associated with the wetland are estimated at £12.45/household for households located close to the wetland and £4.08/household for households located elsewhere in the UK. The aggregate willingness-to-pay estimates over the UK are £32.5 million and £7.3 million, respectively. Note that non-use estimate values of the wetland must be interpreted carefully as the study was not able fully to distinguish non-users from past users (Barbier et al. 1997).

Box 4. Data Sources for NBS case studies

- Estimates of emission differentials for different initial land uses, like forest and grasslands, in Hoosten et al., 2016, in Bonn et al., 2016. Peatland restoration and ecosystem services. Chapter 4, page 75 (table 4.3) (not open access)
- Estimations of emission differentials can be computed for different types of peat and levels of degradation using the “Peatland Code Emission Calculator” available in http://www.iucn-uk-peatlandprogramme.org/node/2523 (open access)
- Estimates of GHG balance after peatland restoration in Harlow, J., Clarke, S., Phillips, M., Scott, A., 2012. Valuing land-use and management changes in the Keighley and Watersheddles catchment, (NERR044) http://publications.naturalengland.org.uk/publication/1287625 (open access).
- Emissions factors for restored wetland and arable land for different GHG in Peh et al., 2014. Benefits and costs of ecological restoration: Rapid assessment of changing ecosystem service values at a U.K. wetland https://onlinelibrary.wiley.com/doi/epdf/10.1002/ece3.1248 (open access)
- Carbon prices: DECC. 2011. A brief guide to the carbon valuation methodology for UK policy appraisal: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48184/3136-guide-carbon-valuation-methodology.pdf (open access).
- Overview of the potential effects of peatland restoration on water quality related final ES in Martin-Ortega, J., Allott, T.E.H., Glenk, K., Schaafsma, M., 2014. Valuing water quality improvements from peatland restoration: Evidence and challenges. Ecosystem Services 9, 34-437. https://doi.org/10.1016/j.ecoser.2014.06.00 (not open access)

2.7. Concluding Statement and Forward Plans

This report has highlighted the key elements of the classical business case and shown how they may be applied to an high-level concept analytical framework (SITE4NBS concept) for NBS, and how a proponent can delve more deeply into the essential elements required to develop broader NBS Business Case using the RISE4NBS stakeholder engagement and co-beneficiaries identification tool. A Business Model Canvas (Table 7) can then be developed that highlights the project specific elements. Using this approach, we can estimate, in monetary and non-monetary terms, the wider impact of the proposed NBS project and define possible actors, stakeholders, investors, in-tangible co-benefits and co-beneficiaries affected by the NBS that are not normally captured through the classical business case models.

We have illustrated the application of CBA for NBS and provided examples of the assessment methodology through case studies. In this way we can define the scale, timeframe and costs involved, defining a pathway towards identifying possible investors in projects that deliver sustainable, resilient urban infrastructure, while accounting for the widest possible benefits, independent of only marketable monetized benefits, providing opportunities to estimate for NPV of the wider intangible benefits that accrue to NBS, and establishing whether they, on the overall, increase societal well-being.

So as to accelerate and guide the green growth transformation the WEF identified that an inclusive green-growth strategy is an essential driver for innovation and creating sustainable wealth in which the governments, investors and international organizations must create the tools to improve global tracking, analysis and promotion of green investment. (World Economic Forum 2013).This green 'growth' may not be delivered through further resource exploitation, but rather thorough the development of synergistic environmentally focussed approaches to creating urban ecosystems, agro-ecology, natural infrastructure based on NBS and the greening of the economy. By creating processes that rely on devolving multiple benefits across the community, or where cross-sectorial growth is enhanced through broadening of stakeholder engagement, we are able to this capture value through the NBS business case model that is inclusive of the multifunctional, ecological and circular processes of NBS. Disruptive technologies, alternate business models, revised and remodelled governance and policy instruments will also be required to provide transformative pathways for the delivery of NBS, and ensure intergenerational security for our global society and the planetary environment.

This work on NBS business case development is ongoing and will continue through the end of the ThinkNature project in November 2019. Further outcomes that will provide resources for broad stakeholder engagement in business case methodology development and application, which will be available on the ThinkNature platform include the following.

- Development of exemplar business cases for specific stakeholder case studies
- International synergies on business case development for international market potential
- Development of this report as a peer-review publication
- Engagement with the EC NBS Task Force 3 on Governance, Finance and Business Models

The following schedule of work and reporting maps out the final stages of NBS business case development for the ThinkNature project, leading up to the inclusion of exemplar business plans for both European and international NBS projects in the ThinkNature Deliverable D7.3 Report on the market potential through synergies in International level.

July – September 2019	Development of Exemplar Business Cases for European Stakeholder Case Studies
September 2-6 2019	Presentation of NBS business plan methods at ThinkNature Summer School in Crete, Greece
July-Sept 2019	Collation of information with ThinkNature International Advisory Board contacts on international case studies
Sept-November 2019	Development and presentation of exemplar Business Cases for international case studies
Sept-November 2019	Completion of peer-review publication from this report for inclusion on special issue on NBS prepared by Task Force 3
November 2019	Submission of D7.3 Report on the Market Potential (of NBS) through Synergies at the International Level

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