International Guidelines on Natural and Nature-Based Features

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Abstract. Natural and Nature-Based Features (NNBF) have been used for decades to support a variety of objectives in coastal and fluvial systems. Coastal and fluvial restoration projects have been used in Europe, the United States and elsewhere either as part of flood risk management strategies or to restore ecosystem functions. Recent flood and storm events around the world have given rise to a range of studies and projects focused on the role of natural and landscape features in flood risk management. A global dialogue about these events and projects has revealed a demand for authoritative guidance on the use of Natural and Nature-Based Features in support of Integrated Water Resources Management. In 2015, the US Army Corps of Engineers (USACE), the Netherlands Rijkswaterstaat and the UK Environment Agency, supported by other federal and international organizations, initiated a collaborative multi-author project to develop and publish international Guidelines on the use of NNBF to support engineering functions for flood risk management. This paper will outline the content of, and rationale for, the International Guidelines and how they may be used to support informed, resilient and sustainable use of NNBF alongside conventional flood risk management measures.

1 Introduction

The achievements of engineering in the 20th century are awesome to consider. Engineering systems built over the last 100+ years have provided the foundation of modern civilization, providing services related to communication, transportation and the resources on which humans depend including food, energy, and water. The portfolio of infrastructure, worldwide, includes tens of thousands of large dams (Mulligan et al. 2020), hundreds of thousands of kilometres of engineered levee or dyke , and countless other structures that have been built in efforts to control the flow of water and reduce flood risks to support the use of land for agriculture, economic and community development. This large-scale engineering has reshaped the earth's landscapes and natural environment.

The performance of 20th century flood risk management systems includes a mixture of results. Such infrastructure systems have certainly averted damages to life and property on the human-engineered landscape. It is also true that these systems have induced risks (e.g., incentivized development behind levees and other structures), are subject to catastrophic failure, and have resulted in a loss of natural habitat and ecosystem services. The challenges of flood risk management are being aggravated by the realities of climate change. Sea level rise, the nature and frequency of storms, and other drivers are increasingly revealing vulnerabilities in flood risk management strategies that were implemented over the last century. Munich RE estimates that global losses in 2020 due to natural disasters was USD$210 billion, of which only USD$82 billion was insured, with more than 8,000 lives lost. The North Atlantic hurricane season included a record-setting 30 storms, 13 of which reached hurricane status. Of the 10 costliest natural disasters in 2020, 6 occurred in the US (munichre.com 2021). The U.S. National Oceanic and Atmospheric Administration (NOAA) tracks weather and climate disasters that produce at least US$1 billion in losses. In 2020, there 22 such events in the US (an annual record) that produced a total USD$95 billion in losses and more than 260 deaths. Since 1980, there have been 285 such weather and climate disasters in the US that have produced cumulative losses of >US$1.8 trillion and >14,000 deaths (ncdc.noaa.gov 2021).

With these challenges and consequences in mind, there is reason to ask what kind of infrastructure investment will be needed in the 21st century? It has been estimated that by the year 2100 the world's population will reach 10 billion, with a consequent increase in demand for the services provided by infrastructure. The World Economic Forum has estimated that between now and mid-century $US100 trillion will be invested in infrastructure development worldwide. This investment will be directed to maintaining existing systems, upgrading aging and outdated infrastructure, and developing new infrastructure. There is widespread acknowledgement that this investment should be designed to support both the

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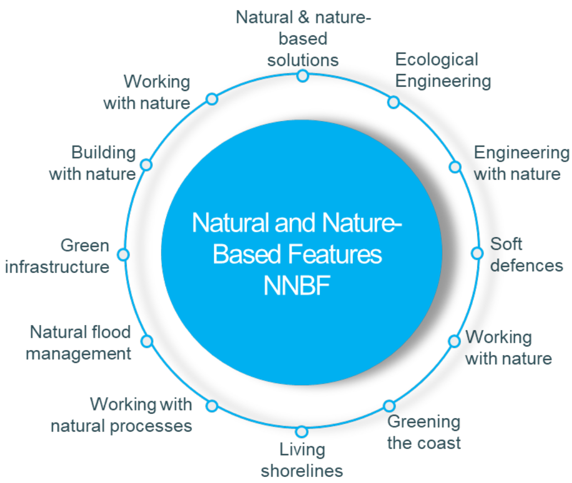
sustainability and resilience of our economies, environment, and social systems. What will such infrastructure systems look like? How will they work? What innovations are needed to deliver them? How can conventional engineering solutions and natural systems be integrated in to increase and diversify the return on infrastructure investment?

The development of future infrastructure systems presents an important opportunity to make more intentional use of the processes and functions found in natural systems in order to strengthen engineering performance and expand infrastructure value. The predominant materials used to develop of 20th century infrastructure were concrete, rock, brick, and steel. The amount of human-produced mass in the form of these materials grew rapidly over last 100+ years, doubling approximately every 20 years since 1900, to the point when human-produced mass now exceeds the total biomass on the planet (>1 tera tonne [Elhacham et al. 2020]). This unsettling milestone in both human and natural history raises serious challenges about sustainability, generally, and begs serious questions about how infrastructure will be developed in the remainder of the 21st century. The historical approach to infrastructure development was guided, to a significant degree, by the use of human engineering to 'conquer' nature, as contrasted with 'collaborating' with nature. The historian and philosopher of technology Lewis Mumford wrote,

"In the act of 'conquering nature' our ancestors too often treated the earth contemptuously, under the delusion that the losses did not matter, since modern man through science and invention would soon fabricate an artificial world infinitely more wonderful than the one that nature provided—an even grosser delusion" (Mumford 1970).

The purpose of the International Guidelines which are the subject of this paper is to inform the use of natural systems and functions to support flood risk management. Within the International Guidelines, flood risk management refers to actions that are taken to reduce future damage to people and property caused by flooding and erosion in coastal and fluvial systems, including actions to address the myriad biophysical processes that contribute to flooding and erosion (e.g., processes contributing to shoreline erosion and loss of land elevation that can increase flood risks over time). Within the International Guidelines the term Natural and Nature-Based Features (NNBF) refers to the use of landscape features to produce flood risk management benefits while also producing co-benefits in the form of other economic, environmental, and social benefits. These landscape features may be natural (produced purely by natural processes) or nature-based (produced by a combination of natural processes and human engineering) and includes such features as beaches, dunes, wetlands, reefs, islands, etc. These landscape features can be used alone, in combination with each other, and in combination with conventional engineering measures such as levees, flood walls, and other structures. The types, number, size, and combinations of measures (NNBF or conventional structures) used within a flood risk management system will be determined by problem context, geographic setting, the goals of the project, and a host of other factors.

As used in the International Guidelines, NNBF represents a type of nature-based solution (NBS). Different definitions of NBS are in use across the numerous and diverse organizations that are advancing and applying these approaches. The common element among all these definitions is the focus on conserving, restoring, and engineering natural systems for the benefit of people and the ecosystems we inhabit. Related, though not necessarily synonymous, terms include ecosystem-based approaches, natural infrastructure, green infrastructure, natural flood management, among others (see Figure 1). The pursuit and development of such approaches stretches across several decades. In the 1960's, the ecologist Howard T. Odum and others developed a foundation for ecological engineering and in 1969 the landscape architect Ian McHarg published his seminal book Design with Nature. These efforts, among others, contributed to the development of what are now called nature-based solutions.



Source: Nigel Pontee, Jacobs

Figure 1. Range of terms which have similarities to NNBF

2. Development of the guidelines

Existing guidance on the use of NNBF in coastal, estuarine and fluvial systems is limited, variable in detail and scattered through numerous and often obscure documents. The NNBF International Guidelines have therefore been prepared to inform future sustainable practice in flood risk management. Use of NNBF, in various forms, has been growing and maturing for several decades and NNBF projects have been built and are successfully operating around the world. Collecting and sharing the international experience on NNBF was a primary motivation for developing the International Guidelines.

The collaborative project to develop and produce the international guidelines was initiated by the US Army Corps of Engineers (USACE) to support flood risk management in the context of the overall sustainability and resilience of our coasts, bays and estuaries. Based on subsequent discussions with the Rijkswaterstaat in the Netherlands and the Environment Agency in the UK, it was agreed to extend the scope to accommodate fluvial systems. All nations involved agreed that considerable confidence in design and construction practices is gained within individual countries by being able to refer to authoritative guidance produced by an international team, which has discussed and resolved differences in practice and identified necessary improvements. Developing the international guidelines has been a multi-author effort that has drawn from organizations across all of the relevant sectors, including government, academia, NGOs, engineering firms, construction companies, etc. The resulting single, comprehensive and self-contained guidelines document was also able to draw from a combination of recent and ongoing research internationally and partly from collation of previously published and unpublished best practice. Source material reviewed included that produced by aid agencies (UNDP, World Bank etc).

The endorsement and participation of national and public organizations as well as private sector firms and academia has been key to the project. Participating partners have gained considerably from the experience and it is expected that participation will facilitate subsequent uptake and implementation by their organizations and associated contractors, including facilitating subsequent training programs. The benefits of international collaboration also include sharing costs associated with producing the Guidelines, enabling organizations to participate in the project at a fraction of the total project costs. The effort to produce the Guidelines has also resulted in an emergent international Community of Practice (CoP), enabling those involved to discuss new and developing topics as they emerge during and after the production of the Guidelines. This CoP will be important if there is an ambition to maintain an electronic source of information beyond the initial production of the Guidelines.

The length of the resulting International Guidelines, at more than 800 pages, itself testifies to the significant amount of experience and technical work that has occurred on NNBF, globally, and which continues to grow. Hundreds of scientific papers and reports related to NNBF have been produced by organizations, researchers, and practitioners around the world during the last five years as the International Guidelines were developed. That said, the purpose of the NNBF International Guidelines is to inform and guide, not to provide an exhaustive summary or analysis of this growing body of technical literature. This guidance is not intended as a 'cookbook' for NNBF with 'recipes' to follow. Nowhere in the International Guidelines will a reader find the NNBF analogy for calculating the size of rock to be used in conventional shoreline armouring projects. The goal for the NNBF International Guidelines is to help inform the process of conceptualizing, planning, designing, engineering, and operating FRM systems that include NNBF. The escalating scale of flood risks and challenges calls for new ways of envisioning solutions, layering, and combining measures, and phasing the development of FRM systems that include the functions and values that nature can provide.

While the target audience was practitioners who would be implementing (designing, creating and maintaining) NNBF measures, the multifaceted and governance-dependent nature of decision-making means that the Guidelines should also be useful to:

- policymakers, NGOs etc seeking evidence to inform their approach;
- stakeholders wishing to understand strengths and weaknesses of NNBF measures; and
- communities wishing to use NNBF measures for flood risk reduction.

3 Organization and content of the NNBF International Guidelines

The NNBF International Guidelines are divided into three major sections. The first section covers a set of common topics that are broadly applicable for application of NNBF. The second section addresses coastal applications of NNBF, inclusive of open coast and estuarine environments. The third major section covers NNBF applications in fluvial or riverine environments. Throughout the International Guidelines, care has been taken to use examples and case studies to illustrate the diverse contexts and progress being made in applying NNBF worldwide.

The International Guidelines are organized so that a reader can begin where their interest guides them, i.e., there was no expectation that someone picking up the International Guidelines would begin on page one and read each chapter in order until the end. The chapters (see Figure 2) were developed in a collaborative environment where there was communication and engagement across chapter teams given the conceptual connections and relationships among topics covered in the chapters. We wanted the chapters to be able to stand on their own, but to also be part of an integrated treatment of the subject of NNBF. Each chapter begins with a listing of key, high level messages within the chapter. All of the chapters include references to other chapters in the document. Icons are used in combination with case studies to draw attention to key topics that are covered in other chapters. To help cohesion of the International Guidelines, discussion throughout is linked to a conceptualised set of stages in a typical NNBF project (see Figure 3)

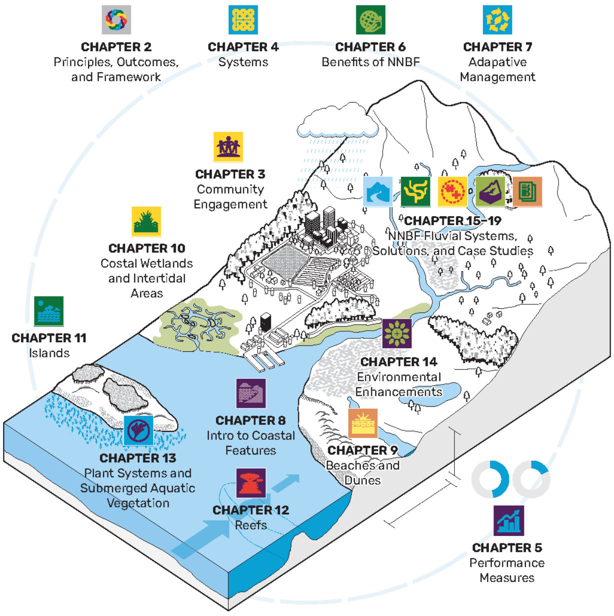


Figure 2. Contents of these NNBF International Guidelines linked to a watershed

Other key benefits of the Guidelines include:

- the collation and coordination of disparate sets of information in order to provide an authoritative guide that practitioners can use without having to search everywhere:
    - providing a portal/links to this information so people can easily access it; and
    - providing a degree of peer review/summary/analysis of the material referred to – in this way bringing added benefit;
- the focus on the need for whole-life design of NNBF measures including adaptive management approaches;
- provision of ways of valuing NNBF flood risk management benefits and environmental and social co-benefits;
- reinforcement of the flexibility / adaptability of the NNBF approach, e.g., by introducing NNBF measures and solutions in adaptive strategy and policy pathways for the future; and
- identification of science/engineering knowledge gaps in order to focus future national and international R&D.

In regard to the last point, we recognized throughout the process of developing the International Guidelines that science and practice in this field is rapidly advancing, so we have plans to provide a future update to the NNBF International Guidelines when the timing seems appropriate to do so.

Figure 3. The NNBF project process

3 Emerging principles for NNBF

Reviewing the breadth of material covered within the NNBF International Guidelines, some general observations and principles can be identified to inform thinking about natural systems and FRM, approaches to implementing NNBF, and future needs.

Natural features and landscapes have always contributed to flood resilience. Since the advent of the modern environmental 'movement' in the 1960s, there has been expanding recognition of the value of nature. This value takes many forms, including values related to functions we now associate with human engineering, e.g., supporting water quality.

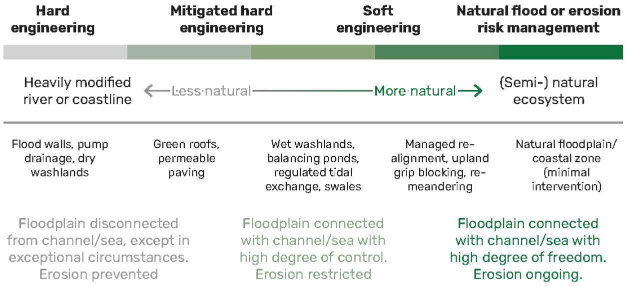
There is a strong and growing interest in NBS around the world. For most of human history, if you wanted to reduce your flood risk you took cues from the landscape and occupied high, solid ground, "…like a wise man who built his house upon a rock." In a sense, the increasing attention being given to NNBF is simply and elevation of this common-sense approach to FRM. In fact, observation and common sense alone can reveal the importance of natural features and landscapes. There are more than 2,000 barrier islands worldwide, occupying more than 20,000 km of shoreline. The US has more than 400 barrier islands (more than any other country) that occupy nearly 5,000 km of shoreline (Stutz and Pilkey 2011). Would the extent of mainland flooding during coastal storms be worse in the US in the absence of these barrier islands? The answer to this question is too obvious to require the use of a mathematical model. A logical extension to this question, relevant to NNBF, would be how can island restoration and/or creation be used to reduce long-term risks from coastal storms? Wetlands are ubiquitous features along coastlines and rivers around the world and wetlands can and do provide valuable FRM functions (Narayan et al. 2017). The loss of these wetlands due to human development, landscape-scale engineering, and other processes has exacerbated FRM challenges. Conversely, conservation, restoration, and creation of wetlands can and will contribute to reducing future flood risks. The International Guidelines layout the use of a broad range of NNBF in support of FRM.

The function and success of flood risk management measures and systems is related to scale. This is true for conventional and nature-based solutions. Ten linear meters of levee will not provide flood risk management benefit, nor will 10 meters of constructed reef or wetland. Engineering interventions must be scaled to match the scope of the FRM problem.

In regard to NNBF, sceptical attitudes about NNBF sometimes take the form of 'strawman' arguments about the insubstantial quality of NNBF, as if we could tiptoe our way to flood risk management by planting a garden of tulips in the right place. However, beaches, dunes, islands, and other forms of NNBF are substantial landscape features that exert a physical influence on local hydrology, hydrodynamics, and other processes contributing to FRM. Some have argued that NNBF may be suitable for frequent, small storms but that such landscape features will not be effective for infrequent, large events. This is a gross generalization that is not supported by careful analysis (e.g. Narayan et al. 2017; Narayan et al. 2019; Storlazzi et al. 2019). Practitioners must also be clear and careful about how NNBF work. A nature-based solution that is implemented to address a local shoreline erosion problem, at the scale of an individual property owner, will not provide immediate flood risk management benefits for that property owner nor for the system as a whole.

Sustainable FRM systems will include combinations of conventional, natural, and nature-based elements. The realities of climate change are forcing acknowledgement of two related facts: 1) human activity affects the global system and 2) human engineering cannot 'control' nature. There is growing recognition that the scope of flood risk management challenges, worldwide, cannot be fully addressed through conventional infrastructure solutions alone. It is not reasonable to think, given the mixed performance of conventional structural measures (e.g., walls and levees), that more concrete, rock and steel alone will be sufficient to address future FRM challenges. It difficult to envision a national or international floodwall or levee building program that could be large enough to address the challenges associated with climate change, sea level rise, the nature of storms, and projected trends in flooding around the world.

Sustainable FRM systems will lie along a spectrum (see Figure 4). At one end of the spectrum, local conditions and constraints may dictate that conventional, structural engineering (e.g., floodwall) will be the predominant approach. At the other end of the spectrum, a FRM system may be wholly nature-based (e.g., beach-dune complex). In the majority of future cases, FRM systems will include a mixture, or combination, of complementary NNBF and conventional engineering. The overarching objectives for informing the design of such integrated systems will be to produce sustainable outcomes that promote the resilience of our communities and environment, while creating long-lasting, diversified value.



Source: modified from XXXX

Figure 4. Spectrum of Sustainable FRM Systems

The flexibility and adaptability of NNBF provide utility for achieving flood resilience. All engineered FRM interventions and measures are dynamic, i.e., they change over time. Conventional structural measures deteriorate with age and can be damaged by storm events. The same or similar processes affect NNBF. As a consequence, all FRM measures require monitoring and periodic maintenance investments.

Because NNBF are predominantly made up of such natural materials as sediment, biomass (e.g., plants), and to a lesser degree rock, it can be argued that NNBF are more dynamic than structural measures made of concrete, rock, and steel. However, the dynamism of NNBF also offers some benefits.

NNBF have the capacity for natural recovery. Because the building blocks of NNBF are natural (e.g., sediments and plants), the environment itself is a source of natural resupply and repair. The restoration of disrupted sediment transport processes could be sufficient to sustain a natural island or wetland that is providing FRM value. When designed and constructed in synchrony with local biophysical processes, the maintenance of a nature-based feature can be supported by 'mother nature'. At the risk of stating the obvious, human intervention is always required—usually at considerable cost—to repair levees and floodwalls.

The adaptability of NNBF as FRM measures provides value with respect to uncertainties. For example, an island that is enhanced or constructed to attenuate storm surge and waves for a community could be expanded in future years if experience and evidence indicate the need for such an expansion in order to increase FRM and other benefits.

NNBF are also amenable to implementation in phases, owing to their dynamic and flexible nature. A FRM study might identify the value of developing a 1,000 hectares of wetlands within an area through a combination of conservation, restoration, and new wetland construction. Such an NNBF project could be implemented over many years in a series of construction phases, in contrast to being implemented in one constructure 'lift' or campaign. In fact, the long-term, phased approach could provide opportunities to coordinate and leverage other activities, e.g., future navigation dredging can provide a source of sediment over time and a means to reduce and share construction costs. Phased implementation of NNBF could be pursued as a part of a multi-year or even multi-decade resilience strategy for a region.

Finally, creating opportunities to benefit from the flexibility and adaptability of NNBF will involve forethought, long-term planning, and good policy, e.g., to conserve the space/land needed to adapt and expand.

The use of NNBF can increase and diversify the value provided by infrastructure. Investment in infrastructure is increasing worldwide in efforts to maintain systems that were built in the 20th century, to satisfying the increasing demand for infrastructure services by the world's growing human population, and to address the risks posed by climate change. This growing investment has stimulated thinking about how to increase the return on investment in infrastructure. The primary motivation for most infrastructure investment has been based on traditional economic considerations. However, NBS provide opportunities to expand the business or value case for infrastructure investment by diversifying the benefits produced, to include additional economic, environmental, and social benefits.

Progress on the science and engineering of ecosystem services that has bloomed over the last 30 years has brought together ecologists, social scientists, engineers, and many others to consider the value of nature and the services and functions nature provides. The advances made in this field and the practical tools that have been developed have enabled evidence on ecosystem services to inform decision making about infrastructure investment. The benefits assessment chapter of the International Guidelines considers these approaches in their application to NNBF and FRM.

Progress in modernizing the evaluation of costs and benefits associated with investment in FRM and NNBF will be key to elevating FRM projects in relation to competing priorities for both public and private investment. The successful integration of NNBF into FRM strategies and systems will support the sustainability of future investments while providing the multi-purpose, multi-functional projects that are increasingly desired and expected by communities.

Innovation in practice will be key to addressing future problems and opportunities. New approaches are needed to address the evolving and growing problem of flooding worldwide.

It is increasingly evident that we live in a multi-hazard world and that our infrastructure systems need to be adapted to address this reality. The hazards and risks we confront take many forms, flood and drought risks, wildfires, environmental challenges brought about by concentrated human development (e.g., water supply and quality, harmful algal blooms), loss of habitat and biodiversity, industrial disasters, pandemics, etc. Most conventional engineering solutions and infrastructure projects in the 20th century served a single or narrow set of purposes, e.g., reducing flood risk. The nature of the multi-hazard world calls for new approaches that expand the functions and services provided by infrastructure systems.

Innovation involves resolving tensions between maintaining established standards of practice and adopting emerging techniques. The International Guidelines are one of many steps being taken to support needed evolution in FRM practice. Innovation introduces uncertainty and risk into practice—doing something new or different almost always does. However, all of engineering practice involves uncertainties and risks that are actively considered and managed as a part of risk-informed decision making. One simple approach would be to always use the 'tried and true' low-risk practice or technique; however, this option is often not affordable, feasible, or ultimately even desirable once benefits are factored into the decision-making process.

Uncertainties and risks exist for both conventional structural FRM measures and nature-based measures. Every year around the world, parts of levees, floodwalls and other FRM structures—which have been routinely used for hundreds of years—fail in a technical sense before their design specifications are exceeded and 'fail' in a more colloquial sense because water levels exceeded the structure's design specifications. Repairs to these structures, and the flood damages resulting from the failures, total many billions of dollars. Uncertainties and risks also exist regarding the engineering performance and long-term operation and maintenance of NNBF. Numerous NNBF projects have been built around the world in recent decades and evidence regarding their performance is being shared and published by an international community of scientists and engineers. A chapter of the International Guidelines on performance assessment and measurement of NNBF provides guidance on this topic.

The pace of knowledge development and technical exchange relevant to FRM is tremendous and this is particularly true regarding NBS and NNBF. This reality of the 'information age' calls for institutions to develop new approaches for scanning, acquiring, and integrating knowledge into policies and practices. Hundreds of technical papers and peer-reviewed publications on NBS and NNBF were written and published during the preparation of the NNBF International Guidelines and hundreds more will be written after the International Guidelines are published. Our approach in developing the International Guidelines was to relevant information and an approach for considering and analysing NNBF within the context of planning, engineering, and operating projects.

Importantly, a commitment is needed from all organizations connected to FRM to innovate, including infrastructure agencies, conservation organizations, environmental regulators, educators, engineering and construction companies, investors, and insurance companies, among others. There is an urgent need to address flood risks worldwide which calls for the need to integrate R&D, scaled demonstration projects, and full-scale projects into an efficient and accelerated approach for delivering solutions.

Policy development is needed to guide and expand the use of NNBF. The primary focus of flood engineering for the last 100 years has been on conventional structural measures; thus, most existing flood and environmental policies are tuned to this application. The NNBF International Guidelines have been developed as the product of international experience, recognizing that policy and governance context varies around the world. While examples from different countries are used or referenced, specific application of the International Guidelines will be based on the policies operating within a specific jurisdiction, governance context, and time.

There are three major areas where policy advancement is needed in Europe and elsewhere to facilitate effective implementation of NNBF:

1. Explicit inclusion of NNBF as a potential source of FRM benefits and updated policies for evaluating the performance of NNBF, structural and non-structural measures in equivalent ways.
2. Policies that provide direction and guidance for considering the full economic, environmental, and social benefits of NNBF, structural and non-structural measures that can be compared to the full costs of implementation over the short and long-term.
3. Approaches for diversifying investment and financing for FRM projects. Public and private sector experience with investment in NBS and NNBF can be used to develop new policies for sharing the costs and benefits of projects and accelerating implementation.

In all these areas, policy evolution (at different rates) is underway in countries around the world.

Coordination, collaboration, and partnership will fuel successful implementation of NNBF. There are many opportunities to bridge organizational boundaries to improve FRM, generally, and to advance the application of NNBF, specifically.

The nature of FRM problems and solutions points toward the need for coordination among the authorities that establish national policy and funding priorities and local authorities that strongly influence, or perhaps largely control, land-use planning and development. Historical policies or practices that allowed or even encouraged development in low-lying areas and floodplains have created flood risks over time. In addition, addressing these risks with engineering interventions requires space, in land or in the water, upon which to construct FRM measures. Flood risks are reduced by creating elevation and roughness on the landscape. In the case of non-structural measures, for example, this can be accomplished by elevating the buildings themselves above flood water levels. For structural measures this is achieved by constructing elevation in the form of barriers such as levees or walls. For NNBF to be effective, enough space must be available to be develop the feature(s) at sufficient scale for the elevation and roughness provided by the feature(s) to influence local hydrology and hydrodynamics. Coordination between national and local government agencies on land-use planning is key to making room for NNBF and the effectiveness of future FRM.

Collaboration is also needed among the organizations and programs that affect the resources and activities that contribute to developing NNBF. One critical example is the need for collaboration among the organizations and programs that engage in navigation dredging and flood risk management. Sediment is a critical construction material for most NNBF. Hundreds of millions to billions of cubic meters of sediment are dredged every year from rivers, estuaries, and coastal areas to support navigation infrastructure and other purposes worldwide. Most of this sediment is discarded, disposed, or dumped in a manner that is intended to minimize operational costs. Coordination, partnering, and cost sharing that enables the beneficial use of dredged sediment to support existing natural features and the construction of nature-based features to achieve FRM will accomplish multiple infrastructure purposes while advancing the sustainability of infrastructure. Coordination and collaboration among the multiple government agencies with regulatory authority over the myriad activities involved in developing FRM projects, and NNBF particularly, are critical to progress. The scope of the challenges posed by climate change and flooding call for innovation on multiple levels, including our approach to regulation.

The size of the challenges, risks, and damages associated with natural hazards is motivating increasing action from a range of public and private sector organizations. Partnering between the public and private sectors is stimulating innovation and new solutions involving finance, insurance, infrastructure, and the non-profit organizations. Given the diversity of benefits that can be produced through NNBF, such projects provide natural partnering opportunities among organizations with different interests and goals.

There is power in collaboration. The NNBF International Guidelines are the product of a collaboration among XX subject matter experts from XX organizations and XX countries and a host of others whose work has advanced FRM practice through the use of NNBF. The world community faces many common challenges related to flood risk management. However, local conditions provide critical context and requirements for designing and implementing a specific solution, including applications of NNBF. Collaborations that draw together collective experience from different contexts provides value that can be shared across the international community. The development of the NNBF International Guidelines over a period of 5 years has also produced a diverse technical community of practice that will continue to provide value as we learn and share our experience with integrating nature into flood risk management.

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