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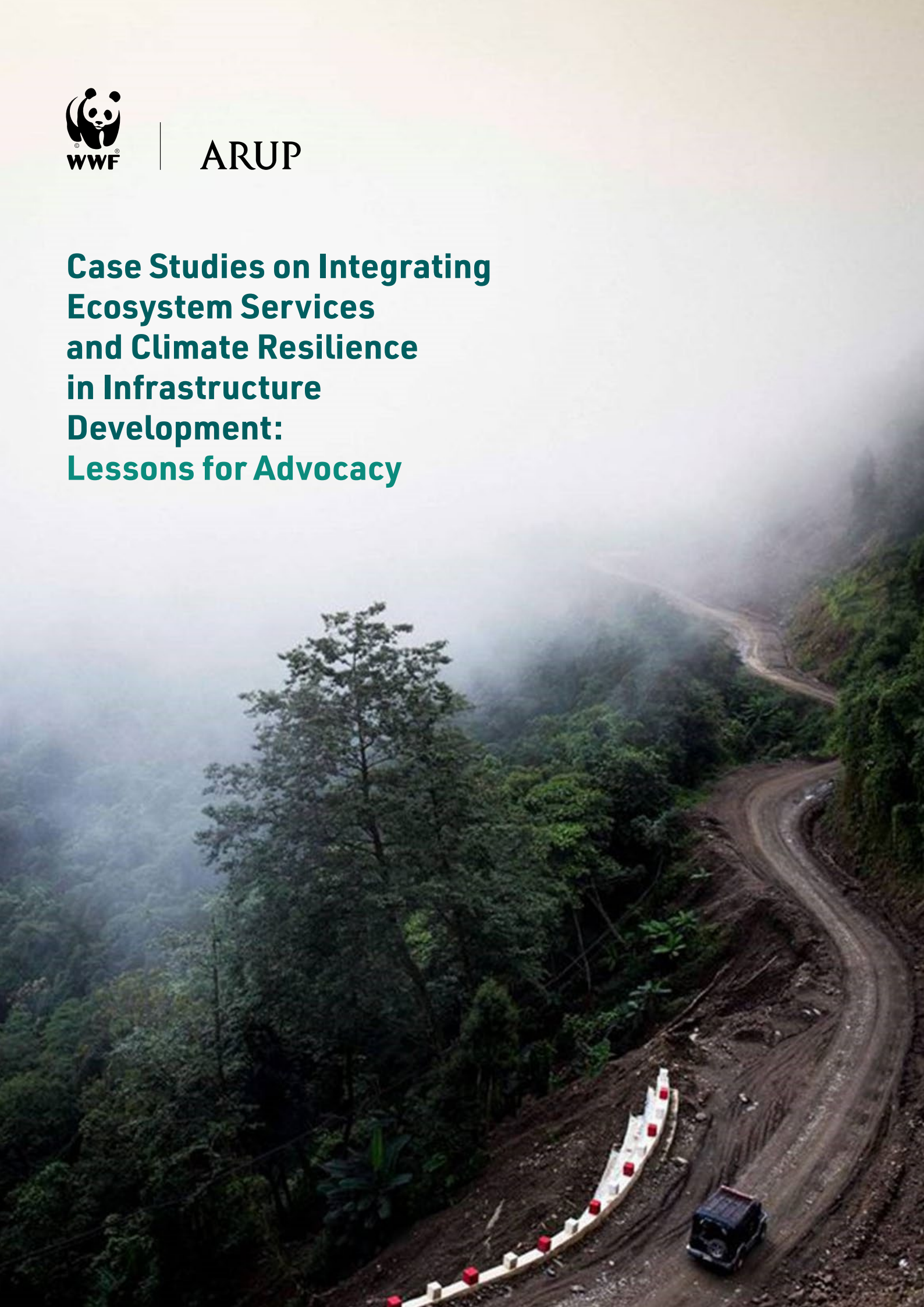
Case Studies on Integrating Ecosystem Services and Climate Resilience in Infrastructure Development:
Lessons for Advocacy



Title

"Case Studies on Integrating Ecosystem Services and Climate Resilience in Infrastructure Development: Lessons for Advocacy"

Cover Photo: Road construction in Chin State, Myanmar

Disclaimer

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of the Federal Republic of Germany

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Contents

Acronyms

ADB	Asian Development Bank
AfDB	African Development Bank
CA-MPO	Charlottesville Albemarle Metropolitan Planning Organization
CESA	Critical Ecologically Significant Areas
CDMX	Ciudad de México (Mexico City)
CONAGUA	Mexico National Water Commission
CPA	Coastline Protection Area
EbA	Ecosystem-based Adaptation
EBRD	European Bank for Reconstruction and Development
EIA	Environmental Impact Assessment
ES	Ecosystem Services
ESCR	East Side Coastal Resiliency
HS2	High Speed 2
HYMOD	Hydrological Model
FHWA	US Federal Highways Administration
GCF	Green Climate Fund
GFCS	Global Framework for Climate Services
GHG	Greenhouse Gas
GIS	Geographical Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IADB	Inter-American Development Bank
ISO	International Organisation for Standardization
LAPSSET	The Lamu Port, South Sudan, Ethiopia Transport
LCDA	LAPSSET Corridor Development Authority
LMCR	Lower Manhattan Coastal Resiliency
MA	UN Millennium Ecosystem Assessment
MCMA	Mexico City Metropolitan Area
NGO	Non-Governmental Organisation
PDC	Planning District Commission
PES	Payment for Ecosystem Services
REF	Regional Eco-Logical Framework
SAC_SMA	Sacramento Soil Moisture Accounting Model
SACMEX	Sistema de Aguas de la Ciudad de Mexico
SDG	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SECR	Shenzhen Eastern Coastline Rebuild
SEMARNAT	Mexico Ministry of Environment and Natural Resources
UK	United Kingdom of Great Britain and Northern Ireland
UN	United Nations
UNDP	United Nations Development Programme
UNSDG	United Nations Sustainable Development Group
USA	United States of America
WB	World Bank
WWF	Worldwide Fund for Nature/World Wildlife Fund

Executive summary

It is currently estimated that over 60% of the land projected to become urban by 2030 is yet to be built on, and that development will mostly take place in the countries of South-East Asia and Africa. While it is likely that the infrastructure will contribute to socio-economic growth, there are also major challenges ahead. Insufficiently funded projects, and limited planning and design capacities to cope with the pace of development may threaten the ecological viability of immense areas. The overall effects of climate change, meanwhile, will influence the quality and availability of ecosystem services, and accrue risks for people and their assets at an unprecedented scale.

Developing infrastructure that anticipates and mitigates its impact on vast ecosystems, and is also resilient to the negative effects of climate change, will require a more integrated and forward-looking approach. National, regional and local master-planning authorities, along with investors and designers, must comprehend the full interplay of human and climate-induced effects on ecosystems; estimate future scenarios induced by climate change; and decide whether, where and what infrastructure should be developed. They should then be able to design it accordingly, and enforce decisions in the long-term. To this end, they will need to mobilise planning skills, rely on strong governance and regulatory instruments, access good quality-design and finance, and demonstrate leadership in decision-making and enforcement over time and across administrative boundaries. This is a challenging task.

There is growing evidence that some countries, financial institutions and designers around the world are developing more holistic approaches to infrastructure development. This report has reviewed promising practices in Africa, Latin America, Asia, Europe and the United States in which developments at a significant scale have attempted to integrate ecosystem services and climate change implications.

In Mexico, the Government of Mexico, with the World Bank, the Rockefeller Foundation and researchers from the University of Massachusetts Amherst, has tackled water resilience and security at scale. Acknowledging that Mexico City is reliant on large water catchment systems and a heavily exploited underground aquifer, the project team has developed an innovative model to integrate future climate scenarios in decision-making. This required working across administrative and ecological regions, in different sub-systems, and subjecting investments to future climate scenarios and stress tests; as well as ecosystem analysis and stakeholder consultations. The human-hydrological model developed through this project was used to evaluate the performance of different proposed investments.

In China, nature-based solutions were proposed to the Public Authority of Shenzhen by Arup, as alternative or complementary approaches to hard infrastructure, in order to maximise benefits such as coastal defence and environmental viability along a coastline of 18 km and a land area of 420,000 sqm. The proposed seawall regeneration project aimed at improving coastal protection to the impacts of climate change, reclaiming lost habitats and their associated ecosystems, and increasing eco-tourism.

This case study showed a strong interaction between authorities and designers, where conventional briefs are questioned and reinvented to maximise benefits and long-term solutions. Nature-based solutions to coastal redevelopment proposed by the designer have influenced the thinking of the authorities tasked with building adaptation and increasing resilience to climate-related natural hazards.

In Kenya, the Lamu Port construction was influenced by a more integrated understanding of ecosystem services and the potential impact of the project. Development has taken place in Lamu guided by the ecosystem services assessments, rendered spatially to maximise the impact on decision-making, and captured in the County Spatial Plan. This case shows how articulated policy directions are essential to plan and develop sustainable infrastructure, and how stakeholders are able to seize the opportunity. Examples in the UK, US and Denmark also demonstrate that technical instruments exist for planning and designing sustainable and resilient infrastructure at scale, provided there is a conducive regulatory environment.

Key trends emerging are that all successful practices share an element of innovation, cut across disciplines, attempt to integrate ecosystem and climate change approaches in the same project, and successfully negotiate the overlapping administrative layers at a large scale. Moving forward, there is a need to advocate for adopting these practices more widely.

Many of the international funding institutions seem open to developing more integrated approaches that combine ecosystem, social, and climate change analysis to inform project design. However, this largely remains at the guidance level, while specialists are recruited by discipline and are seldom requested to work across the board. Successful examples demonstrate recruitment of specialists early in the process so that the planning and design of infrastructure can be more holistically influenced. Achieving integrated approaches will therefore require procurement processes to adapt, embedding integrated approaches in tender notices and budgets, and ultimately manifesting in the recruitment and management of expertise.

Strategic Environmental Assessments are progressively integrating climate change. However, they are often challenged by the reality of large-scale project implementation, finance, and changing political agendas. All promising practices have successfully dealt with administrative and institutional complexity over time, thanks to forward-looking policies and authorities. While this cannot be simply replicated across regions, countries and political systems, advocating for support to developing countries in the area of governance and planning for infrastructure can go a long way to establishing a conducive environment.

Planning authorities face a daily conundrum of having to keep up with the fast pace of infrastructure development, balancing social and environmental trade-offs, and considering the potential effects of climate change. The cases reviewed involved a degree of technical support from value-driven private, non-governmental and academic agents. The innovations introduced required technical specialism and the ability to cut across disciplines. It is therefore crucial that technical assistance is budgeted in the short term; and in the longer term that capacities in environment, climate change, design and planning are built in countries that are developing infrastructure.

While this review highlights promising trends, the evidence base is small. There is an urgent need to increase technical and financial support to help countries resolve trade-offs, reconcile values and establish an acceptable balance between fast-paced development and ecological viability. This argument must be made more clearly and soundly on the back of the SDG and Paris Agreement processes.

Aerial view of Dawei Road, Tanintharyi River and surrounding forests in the Tanintharyi region of Myanmar.

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Introduction

A global challenge for the planet and biodiversity...

It is estimated that over 60 percent of the land projected to become urban by 2030 is yet to be built[1]. By some estimates as much as 25 million km of new paved roads are foreseen by 2050, with 90% of construction in least developed and developing countries[2]. Population and urbanisation trends also show that urban growth and infrastructure development will mostly take place in countries in South-East Asia and Africa.

While infrastructure development is regarded as an opportunity for socio-economic development[3], the expected growth will likely also further the already immense burden on the planet's finite resources and ecosystem services, as it will encroach on some of the last remaining intact habitats. Additionally, the anticipated effects of future climate change will continue to modify both shock and stress profiles. In these conditions, the compound effect of infrastructure development, and the effects of climate change on hazard levels and natural processes challenge sustainability. In places without comparative advantages for economic development, due to low levels of investment in resilient infrastructure design, poor environmental planning and poverty, people will face heightened risks of climate-related disasters. At the same time, the natural capital[4] and ecosystem services that benefit societies may be severely affected.

Critically, projected infrastructure growth will mostly occur in countries with less experience[5] in ensuring that planning, technical and regulatory capacities help mandate the sustainable development of infrastructure. The pace and scale of infrastructure development is largely dictated by the pressure to enable economic growth and attract private investment. There is ample evidence, however, that this pace can overwhelm capacities of national, regional and local authorities responsible for land-use management and large-scale development in countries of the global south. Furthermore, the Global Infrastructure Hub estimates that there is a projected $15 trillion gap between projected investment and the amount needed to provide adequate global infrastructure by 2040[6].

... and for planners, authorities, investors, designers.

Keeping-up with the pace of infrastructure development despite insufficient planning, regulatory and financial capacities, may push some countries to accept unsustainable trade-offs, which hamper their long-term development[7] and resilience. In practical terms this manifests in sub-standard infrastructure planning, design and construction, and large impacts on environment and increased risks for people. This is even more likely in large-scale infrastructure development, such as development corridors, which cut across administrative boundaries and, at times, international boundaries. These encroach on delicate ecosystems and heighten exposure to climate risks, with limited proven economic "trickle-down" benefit to local communities.

Unsustainable planning and development of infrastructure does not seem to depend on a lack of technical or design instruments. Since the 1990s practices have been developed to understand the potential impact on environment, including at large-scale, in particular through the development of Strategic Environmental Assessments (SEA) and Environmental Impact Assessments (EIAs). In the last two decades Climate Risk Assessment practices have also been developed and adopted in planning and designing infrastructure at all scales.

In June 2019 the International Organization for Standardization (ISO) published 'ISO 14090: Adaptation to climate change: Principles, requirements and guidelines.'[8] Actual standards to conduct assessments are still under preparation. Ecosystem service mapping practices are also being developed, and nature-based solutions, adaptive and resilient infrastructure design have been devised and improved in the last two decades by city-authorities and designers. A range of policy instruments and tools which can influence the integration into infrastructure planning exist, such as financial frameworks by Development Banks; multi-stakeholder approaches; ecosystem-based approaches; and natural capital valuation software and tools.

Comprehending the full interplay of factors involved in planning, designing and implementing large infrastructure projects; taking decisions based on this knowledge; and enforcing them in the long-term and at large territorial scale, is a complex process. To do so, planning authorities, investors, designers and industry need to consider the potential effects on ecosystem services, and estimate future scenarios induced by climate change, to decide whether, where and what infrastructure should be developed. To this end, they should be able to mobilise planning skills, rely on governance and regulatory instruments, access good quality-design and finance, and demonstrate leadership in decision-making and enforcement. This needs to be done over time and across administrative boundaries at large-scale.

This is a challenging task. However, there is evidence that countries, cities, financial institutions and designers around the world are beginning to adopt more holistic approaches for developing infrastructure at large-scale.

Identifying holistic approaches to sustainable infrastructure planning, design and development

With this case study review, World Wildlife Fund, supported by Arup, has set out to identify promising case studies that have acknowledged this complexity and attempted to address it at different scales. This study has therefore identified several case studies in Asia, Africa, Latin America, the US and Europe that are interesting and promising. This geographical breadth accounts for variations in habitat types (and by association ecosystem services), climate and the regulatory or legal environments, therefore enabling the outcomes of this research to be applicable globally.

It also reviews existing frameworks from international financial institutions and development partners, which are involved

in financing sustainable infrastructure, to assess the level of awareness and interest that exist in the industry landscape.

The purpose of this work is to establish initial evidence that these approaches are being adopted successfully in different regions in the world, and that they could be replicated to ensure infrastructure development in the next decade yields the expected benefits, without trading off sustainability and climate resilience.

Approach to the Study

The study has analysed a range of different projects worldwide and has progressively refined and clarified the scope and scale of these examples. To do this, an extensive literature review of the following sources has first been carried out to compile a longlist of over seventy case studies:

- International financial institutions e.g. World Bank (WB), Asian Development Bank (ADB), African Development Bank (AfDB), Green Climate Fund (GCF);
- United Nations agencies (e.g. UNDP);
- Multilateral and bilateral institutions and development agencies e.g. the European Union, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ);
- National and regional governments;
- Designers (e.g. Arup, One Architecture)

The case study examples capture a wide range of scales, from very large regional development plans, to spatial plans and masterplans and, at the smallest scale, individual or local infrastructure projects. This is to ensure that the different processes, stakeholder types and regulatory or legal frameworks that may be engaged across the different scales are fully captured and appreciated, making the learning outcomes more widely applicable.

The most relevant case study examples to this research have been identified from the longlist by scoring appraisal criteria, which relate to key characteristics of the development strategy or plan. The appraisal criteria are:

- Scale of development;
- Investment and spatial planning;
- Ecosystem services baseline assessment;
- Climate change risk assessment;
- Non-climatic risk assessment;
- Impact on ecosystem services;
- Vulnerability to climate change;
- Design solutions;
- Planning, legal and governance;
- Sustainable finance; and
- Monitoring and reporting.

Having identified case studies across these regions, semi-structured interviews were then carried out with key stakeholders. The varied backgrounds of the stakeholders, which include staff of financial institutions, government, NGOs and designers, and the perspectives they offer, has enabled broader insight into each case study.

The following presents the findings of both the desktop analysis and interview feedback for the selected case studies of regional development plans, spatial plans, masterplans or infrastructure projects.

Case studies

CASE STUDY

Mexico

WHAT

An integrated basin management plan to increase water resilience and security

WHO

World Bank, the Rockefeller Foundation, researchers from the University of Massachusetts Amherst, the Government of Mexico

WHY

Approaching the issue of water supply at a catchment level which encompasses three sub-systems, an innovative model was developed which allowed the project team to assess investment options in the context of multiple future climate scenarios.

This case study looks at the catchment areas in the valley of Mexico which supply water to the population of Mexico City. Mexico City is reliant on the Cutzamala and Lerma water catchment systems, and a heavily exploited underground aquifer. Pumping water from this underground aquifer to supply the city results in continuous subsidence, damaging urban infrastructure, and posing further challenges to water supply. In collaboration with the World Bank, the Rockefeller Foundation and researchers from the University of Massachusetts Amherst, the Government of Mexico developed an integrated basin management plan to increase the resilience of water supply to Mexico City.[9] This plan was developed both to respond to an already stressed water system, and to take into account future shocks and stresses on the system due to climate change and population growth. It was formed around four pillars; (i) existing Cutzamala infrastructure; (ii) water supply and sanitation services; (iii) irrigation services; and (iv) soil and environmental conservation.

Spatial and ecological context

The Mexico City Metropolitan Area (MCMA) is home to 21 million people[10], making it the largest metropolitan area in the western hemisphere. This is predicted to grow to 24 million by 2030[11]. With a wet season between June and September, the city is subject to heavy rainfall and flash floods. During the rest of the year, Mexico City is reliant on the Cutzamala and Lerma water catchment systems (accounting for 39% of the city's water supply) and a heavily exploited underground aquifer. Pumping water from this underground aquifer to supply the city results in continuous subsidence from 4 to 24cm annually, damaging urban infrastructure and posing further challenges to water supply. Future population growth and increasing shocks and stresses due to climate change mean that increasing the resilience of water supply to the city has become an urgent priority.

With this in mind, the Government of Mexico initially approached the World Bank to do a diagnostic of the aqueduct in the Cutzamala system and other grey infrastructure which needed maintenance.

| *Streets of Mexico City*

However, after some preliminary studies, they agreed to adopt a holistic approach, looking at water supply at a catchment level and combining the separate systems into one larger system, to identify vulnerabilities and ensure long-term sustainable solutions to their water supply issues.

Despite previous environmental studies, at the point when the government began adopting this approach to freshwater resilience, much of the surrounding ecosystems were already significantly damaged. For example, much of the Lerma river had been affected by untreated or under-treated wastewater being discharged into the river for several decades.

In these circumstances, this freshwater resilience approach was expected to have significant positive impacts on the surrounding ecosystems, increasing the provision and regulation of ecosystems services. As part of the work done to improve freshwater resilience, key ecosystem indicators were measured, including aquifer depletion rates in Lerma and Mexico City, and divergence from natural streamflow for the Cutzamala water system.

However, the project found that the existing ecosystem was already severely damaged due to decades of neglect and exploitation, challenging the idea of an ecosystem services 'baseline'. While the project is expected to improve ecosystem services overall, this makes it difficult to measure the positive effect in comparison to untouched ecosystems.

Approach

To begin, the work framed the supply of water to Mexico City (CDMX) through consultations with local stakeholders to assess the vulnerability of the whole system across multiple future scenarios. Through a collaborative planning approach, local stakeholders were consulted over a period of two years to define their aims and metrics of success for the water system.

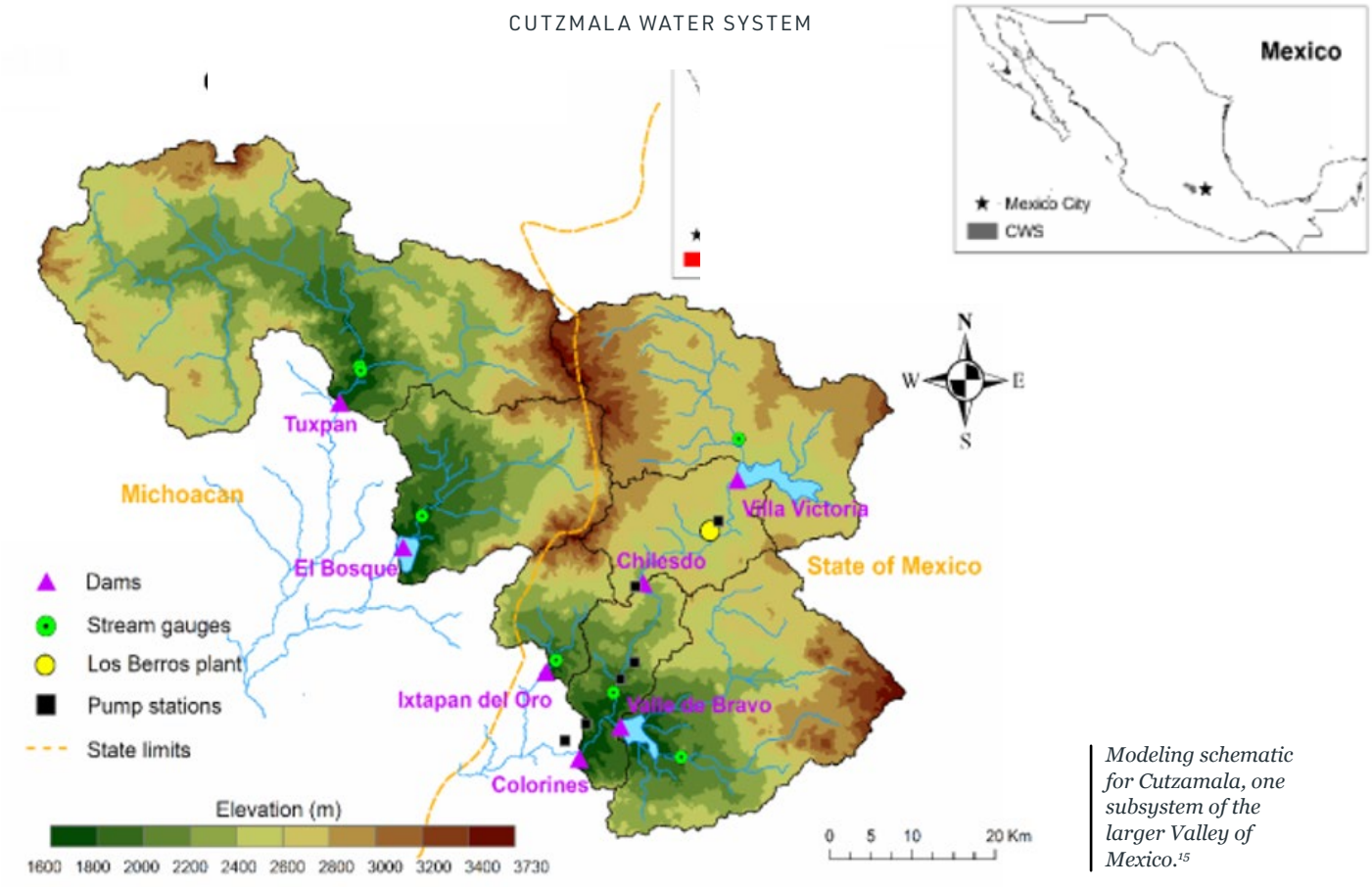
For the Lerma and Cutzamala system, this led to an increased focus on environmental management as stakeholders were keen to see the restoration of the water systems, including natural lagoons. There was also a focus on increasing recharge to replenish the natural aquifer, and understanding the impacts of climate change on the system. This consultation process also worked to build ownership of the project among stakeholders. Having assessed the performance of the current system of water supply, they then considered potential future hard infrastructure and operating rules to assess the potential impact of these investments on the performance of the system to provide a more resilient supply of freshwater.

This project focused in particular on future service provision under the effects of climate change. Researchers at UMass Amherst developed hydrological models for Cutzamala, Lerma and Mexico City. These models were designed to consider the complexities of inter-basin water transfer involving reservoirs, tunnels, open channels, pipelines and viaducts. The performance of this complex system supplying water to Mexico City was then evaluated under multiple climate futures as a climate stress test.[12]

This approach also included a non-climatic risk assessment, identifying other potential future risks, or uncertainties, through discussion with stakeholders. Non-climatic risk factors were changes in the patterns of demand, seismic risk for infrastructure, and project financing risks. For each investment option these risks were considered to assess the effectiveness of planned infrastructure to alleviate the water supply problem.[13]

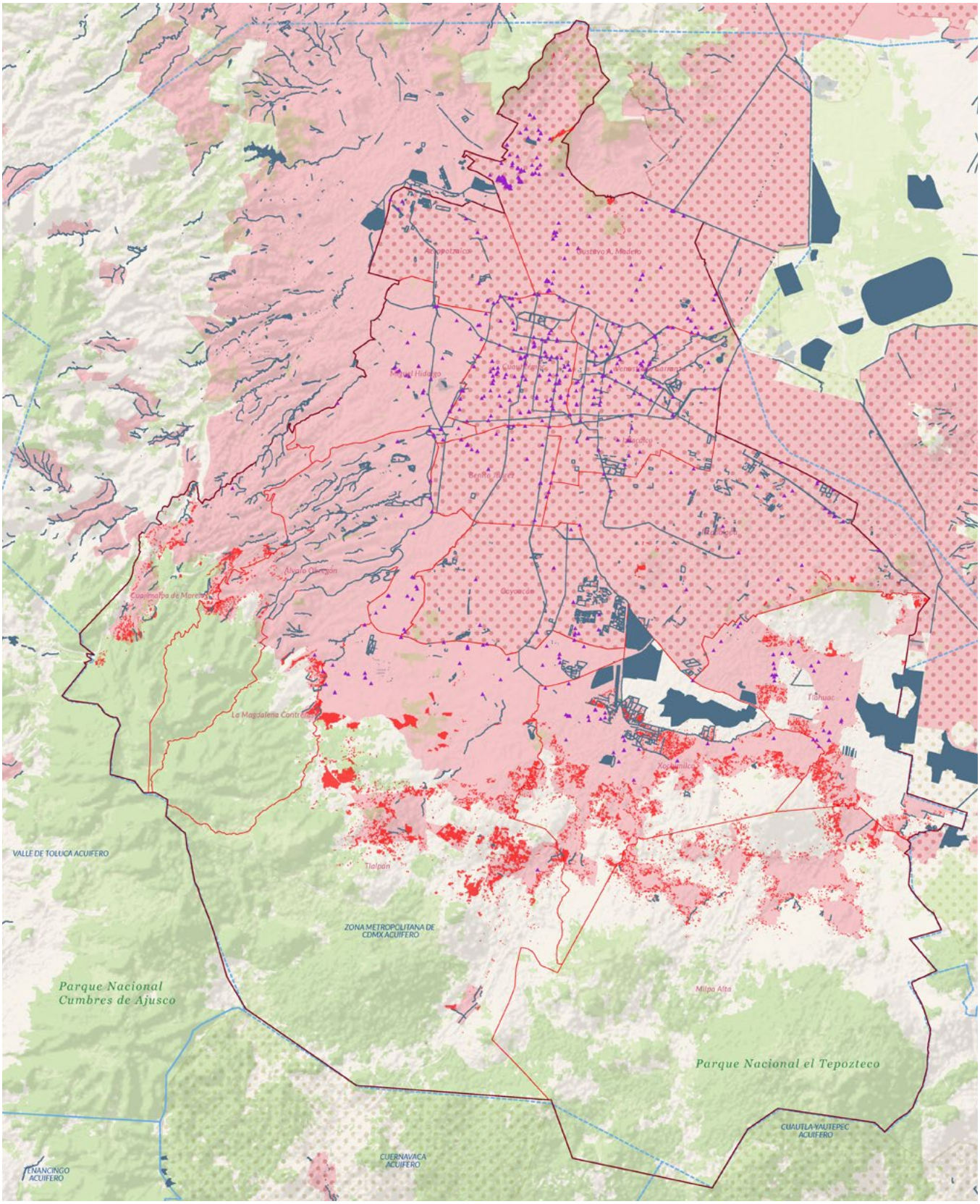
The planning conditions in this case were complex as planning, institutional, legal and regulatory boundaries do not typically align with water catchment boundaries. The MCMA has multiple public institutions in the water sector performing different roles. The National Water Commission (CONAGUA), under the Ministry of Environment and Natural Resources (SEMARNAT), works at national level, providing delivery of water to the area. CONAGUA also forms basin councils which are its legislative branches, created from representatives of relevant ministries, state and municipal representatives, civil society, users and citizens. Sistema de Aguas de la Ciudad de Mexico (SACMEX) is Mexico's federal district water operator, responsible for providing potable water, wastewater treatment, drainage, sewage and water reuse[11]. With different institutions and legal frameworks operating across the valley of Mexico, coordinating a resilience approach for all water supplies into MCMA presented a challenge.

In this context, the basin councils were a positive, becoming the entry point for the project team to engage with a range of stakeholders as they already had the legitimacy to bring together different user groups across the whole catchment area.



Modeling schematic for Cutzamala, one subsystem of the larger Valley of Mexico.[15]

By contrast, the existing regulation system for groundwater withdrawals presented a challenge. Farmers are allowed concessions on the price of water by CONAGUA, but the volume of water allowed through concessions is already greater than the total sustainable yield from the aquifer, due to decades of either miscalculation or corruption. Additionally, CONAGUA has limited enforcement powers, making it unlikely that farmers will be caught and fined, and leading to excessive and unexpected withdrawals of groundwater, thus also increasing uncertainty in the planning process[16].



Mexico City basin map

(credit: George Beane, Arup)

Outcome

The human-hydrological model developed through this project was used to evaluate the performance of different proposed investments. The project team assessed each investment option through this model to analyse the maximum yield, increase in resilience of the system and cost of the investment. Each option could then be compared across these factors and inform decision makers which would represent the best investment.

After assessing additional political considerations, a pressurised pipeline (the Villa Victoria pressurised canal) was determined to be the best option for investment, expected to increase the yield by about 20%. This pipeline is in the planning stages and is close to approval.

The process has also led to an increase in the quantity and quality of data available to local institutions, including a deeper understanding of the requirements and expectations of user groups. Through the collaborative planning approach and custom-built models, local authorities have increased decision making capacities, which take into account future changes in the systems and the complexity of how Mexico City's water systems interact.

The effects of the planned infrastructure on ecosystems services are still to be seen.

Rainwater harvesting system in Mexico City

(credit: IslaUrbana.org)

Why is this interesting? Key lessons

This project brought together three different sub-systems – the Mexico City aquifer, the Cutzamala system and the Lerma system – into one total system supplying water to CDMX, through a series of consultations with stakeholders and the use of hydrological models. Taking a holistic approach that looked at the surrounding water systems enabled the government to make decisions based on the overall resilience of the system. Two key lessons may be extracted, to inform overall findings:

First, the positive interaction between academic, development actors and institutions enabled the development of an innovative method – the human-hydrological method. The model also allowed the team to assess investment options to improve the system, while considering future climate scenarios. This type of rigorous modelling to help inform decision making will be a powerful tool as cities are increasingly faced with climate uncertainties. While the team focused on water provision, this case demonstrates that it is possible to consider future climate change impacts on ecosystems services, and improve infrastructure planning in practice.

Second, sound and innovative technical solutions have been developed on the back of strong stakeholder relationships across multiple authorities and boundaries. This was key to the success of the project as well as the collaboration between government, the World Bank and the University of Massachusetts. Pre-existing basin councils facilitated this cross-boundary co-operation more easily than might have been possible otherwise.

Replicability

The tools used as part of this freshwater resilience planning are advanced, but not entirely inaccessible to other practitioners. The collaborative approach of this project has meant that the models used have been shared with local authorities and they can continue to be used for future infrastructure planning. With the appropriate technical or academic support, it seems likely that this approach could be applied in other places where multi-layer governance between national, regional, city and catchment boundaries works effectively. However, this example also shows the importance of a governance system that supersedes political considerations to enable long-term planning and implementation of infrastructure.

Tools

The human-hydrological model was built through a collaborative planning approach which constitutes in-depth consultations with stakeholders to define the aims of the total system and the variable of interest. This approach has previously been used by hydrology companies and the US Army Corps of Engineers to build ownership in the modelling process, and is widely transferable.

A series of system and hydrological models were built to assess climate and non-climatic risks by researchers at UMass Amherst. In addition to this, standard models such as HYMOD and the SAC_SMA (Sacramento Soil Moisture Accounting Model) were customised by the researchers, and established future climate scenarios were used for the climate stress tests. These models and tools have been shared with government counterparts in Mexico City through training sessions and ongoing support, who expect to continue using them to inform future planning.

Although custom-built for Mexico City, the models are intended to be open source, with an online tool, OpenAgua currently under beta development.

This project adopted and built on the decision tree framework already used by the World Bank. The decision tree framework is a decision scaling approach which provides a method for robust decision making under the uncertainty of climate change for resource-limited project planners and programme managers. For Mexico City, this framework was specifically adapted to include non-climate uncertainties such as economic, demographic or political, thus expanding its approach to risk assessment to identify projects which will perform well across a range of future conditions.[17] This tool is shared as part of the World Bank's Open Knowledge Repository.

CASE STUDY

Kenya

WHAT

The Lamu Port, South Sudan, Ethiopia Transport (LAPSSET) Corridor Project is a regional development strategy, and a flagship project of Kenya's Vision 2030.

WHO

LAPSSET Development Authority, WWF, National Exchequer of UK Government

WHY

The project used economic and environmental policy guidance from the national down to local levels to ensure infrastructure is planned and developed in a more sustainable manner. Habitat mapping at the outset allowed authorities to protect ecosystem services by designating some areas off-limits for construction, and influenced the location of the port.

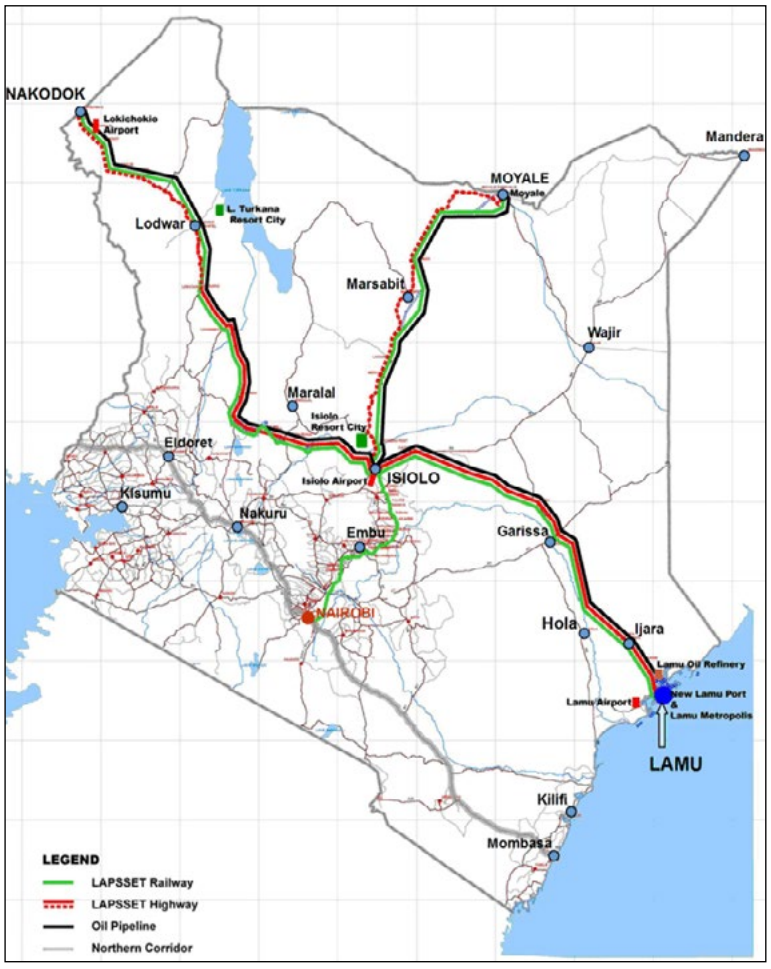
The case study representing Africa looks at the LAPSSET Corridor Project, a long-term regional development strategy comprising, among other features, a port, highway, railway and oil pipeline. Development that has already taken place in Lamu has been guided by the ecosystem services assessment included in the County Spatial Plan mandated by the Constitution of Kenya.

Spatial and ecological context

The Lamu Port, South Sudan, Ethiopia Transport (LAPSSET) Corridor Project is a regional development strategy and flagship project of Kenya's Vision 2030, the country's development programme from 2008 to 2030. Vision 2030 has the objective to help transform Kenya into a "newly industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment." As part of this programme, LAPSSET was proposed by the Kenyan government to increase socio-economic development across the country by improving transport links and encouraging industrialisation.

LAPSSET Corridor Development Authority (LCDA) was formed in 2013 by the Kenyan government to manage the strategy on its behalf. Specific projects led by LCDA include a new port, railway, highway, oil pipeline, several international airports and resort cities. The project is still in its infancy and consequently only a handful of projects have been realised. The first of these is the Lamu Port building in Manda Bay, located approximately 300 km north of Mombasa. The first three out of a total 32 planned berths are currently under construction at Lamu Port.

Although the strategy, funded primarily by the National Exchequer of the UK government, comprises projects in Kenya, it also connects three adjacent countries in the region via the transport proposals: South Sudan, Uganda and Ethiopia.



Map showing the scope of the LAPSSET Project within Kenya

Approach

The Constitution of Kenya has appointed the Environmental and Land Court – with the status of High Court in the country – to address escalations from environmental tribunals regarding the issue of development licenses. Development licenses in Kenya, including for LAPSSET projects, are required to comply with four key legislative acts relating to ecosystem services.

The Kenya Physical Planning Act 1996 mandates that all developments should consider, as appropriate, master, regional or land use planning, to ensure due consideration is given to the socio-economic impact of the project, for example by attributing fair compensation due to relocation. The Kenya Environmental Management and Coordination Act 2015 aims to establish an appropriate legal and institutional framework for the management of the environment. The National Land Commission Act 2012 allows for devolved governments to manage land-use issues, while the County Governments Act 2012 stipulates that County Spatial Plans shall give effect to the principles and objects of county planning.

In the case of the LAPSSET Corridor Project, ecosystem services have been considered both at the individual project and the wider strategic scales. For example, at the project level, the Lamu County Spatial Plan 2016-2026 (2017) includes a land-use zoning profile which maps the critical habitats and, by extension, the provision of ecosystem services.

Both terrestrial and marine habitats were analysed for LAPSSET projects in Lamu as required by the Lamu County Spatial Plan. These include forests, grasslands, mangroves, water sources, beaches, seagrass beds, coral reefs and fishing areas, all of which provide important ecosystem services to the area and, due to historical development, are known to have reduced in capacity. For example, the country has already lost almost 40% of its mangroves in the last 30 years, mostly from Lamu County, and the County today hosts some 70% of Kenya's total mangrove stock. Surveys have also been carried out on fish stocks, but additional surveys are required to determine the impact of the work in comparison with the 2016 baseline.

Ecosystem services for the LAPSSET at the highest strategic level have been considered principally by a Strategic Environmental Assessment (SEA). The draft SEA, published in 2016, documents the plans and issues raised by nearly 1,900 stakeholders in over 40 meetings across Kenya. The following six questions were framed to focus the SEA Study:

1. What are the defining features of the Northern Counties targeted to be transformed through LAPSSET?
2. How well is LAPSSET attuned to drive the economic transformation?
3. What is the prevailing legal regulatory, policy, institutional and strategy framework?
4. What opportunities are available for LAPSSET?
5. What are the social and environmental costs attendant to achievement of LAPSSET goals?
6. What measures need to be put in place to secure gains anticipated under LAPSSET?

The impact analysis of the SEA addresses three different perspectives:

- The compatibility/relevance of the plan to government planning goals at national, regional and county levels;
- International standards for sustainable development, and
- Stated stakeholder concerns and interests.

The SEA continues by identifying major concerns for the corridor, including impact on land use, water, wildlife, and conflict that may consequently arise. These concerns are to be counteracted by adopting the required policy adjustments, legislative action and Strategic Action Plans. The SEA calls for follow up action, such as full Environmental and Social Impact Assessments for all LAPSSET projects; Resettlement Action Plans for displaced people, prepared in full consultation with stakeholders; and a tentative approach with regards to developing specific projects where environmental concerns remain. Environmental, social and governance impacts have also been considered upstream of the projects at the planning stage, as financial appraisal guidelines from the African Development Bank (AfDB) have been adopted by LCDA for raising capital.

A traditional fishing dhow

Lamu seascape, Kenya

© Jonathan Caramanus / Green Renaissance / WWF-UK

Outcome

Kenyan regulations, specifically the Lamu County Spatial Plan, have positively impacted on the development of Lamu port by influencing its location, and designating some areas as off-limits for construction. This is to account for the existing habitats, for example mangroves, and the critical ecosystem services they provide.

Lamu mangroves

Five of the seven species of marine turtle are found in the waters of Kenya's Lamu seascape.Of these, green, olive ridley and hawksbills are known to nest in Kenya. In Lamu seascape, nesting season is March to August.

© Jonathan Caramanus / Green Renaissance / WWF-UK

Why is this interesting? Key lessons

The LAPSSET Corridor Project is an exemplar of how ecosystem services can be integrated into both strategic and project-level plans for regional-scale infrastructure projects. This case study has demonstrated the ability of government bodies to work across administrative layers and across borders. Three key lessons can be extracted here:

First, the stakeholders have seized the opportunity offered by an articulated policy environment to promote sustainable and resilient planning of infrastructure, and enshrined these principles in the development plans. The Constitution of Kenya 2010 has enabled ecosystem services to be fully considered at a local level under the guidance of County Spatial Plans. County Spatial Plans for each zone in Lamu identify ecosystems and protected areas. The County Spatial Plans document their permitted use for development and land use regulations which has impacted development in Lamu specifically because areas around the port have been designated as off-limits for construction.

Second, the innovative use of geo-referenced methods was applied to illustrate the potential impact of infrastructure development, and influence decisions. This was done with help from a local NGO with expertise in habitat mapping. In this instance, the requirement for County Spatial Plans is an enabling factor, as it required the consideration of habitats and associated ecosystem services.

Third, the proper use of the SEA allowed identification of solutions to challenges raised during construction of the port, and addressing them with sustainable impact-mitigation in mind. Dredging constraints identified during construction helped protect existing seagrass and mangroves, while innovative liquid and solid-waste solutions helped minimise the port's operational impact on surrounding ecosystems. The SEA for LAPSSET aimed at preserving the wildlife habitat in coastal lowlands. The SEA states that development of the transport corridor will be required to be moved 10 km east of a riparian reserve which is known to be a crucial watering spot for many wildlife during the dry season. This is to ensure a barrier for wildlife trying to access the water is not created.

Replicability

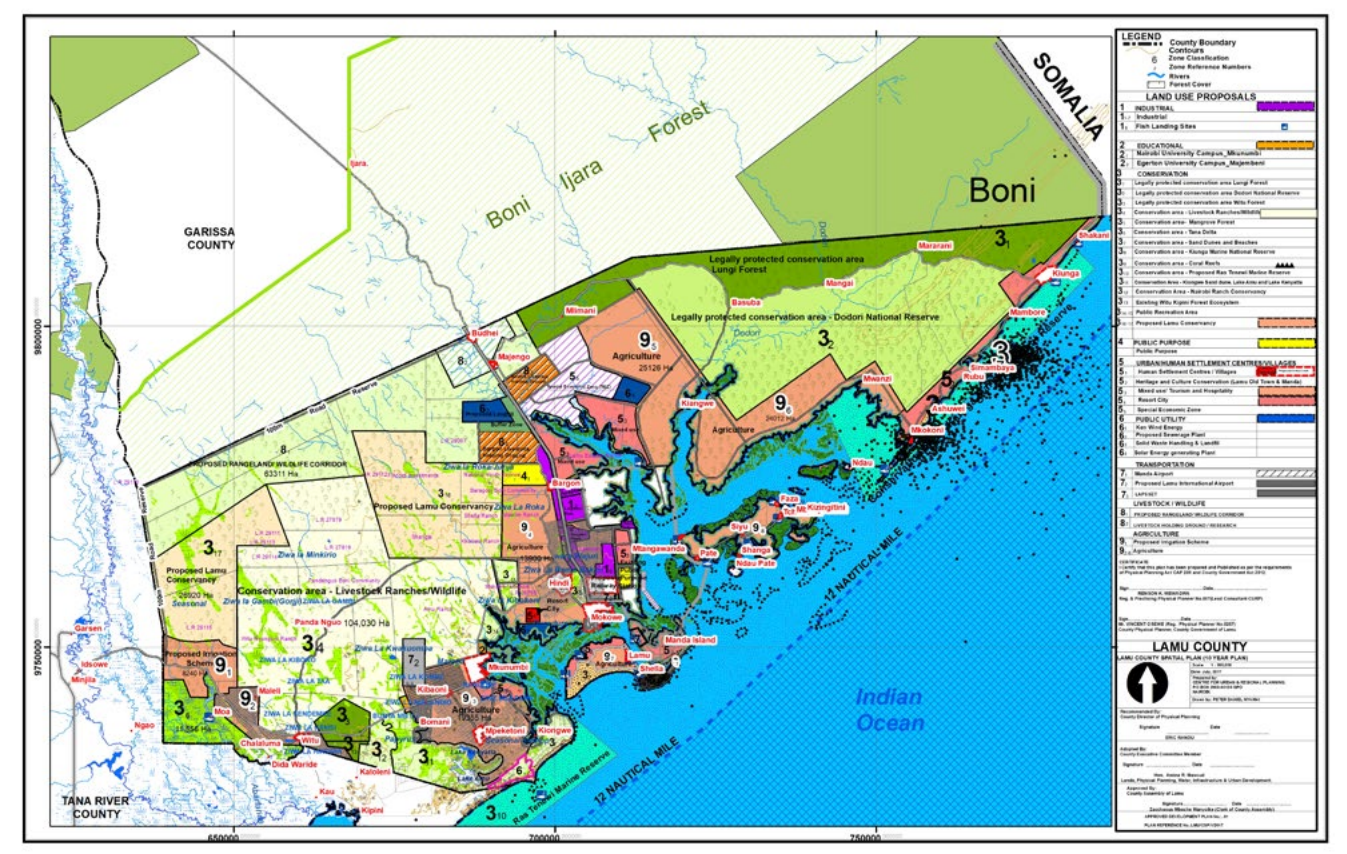
The example of the development of Lamu Port presents an opportunity for the Development Authority to replicate the integration of ecosystem services enabled by the Lamu Spatial Plan across the wider LAPSSET Corridor Project in Kenya. Local governments of other countries can learn from this example about the importance of spatial plans as a blueprint to assess ecosystem services on a local level, in the context of the planning and construction of major infrastructure projects. Parameters derived from the example of Lamu Port may be used to inform choices of nature-based and climate resilient solutions for infrastructure globally.

This case study has proven technically feasible and worth replicating and expanding at scale. This has been enabled by positive relations between designers, the Government, and NGOs. Cost-benefit analysis, and integration of climate change could help defuse concerns around the cost of the intervention.

Tools

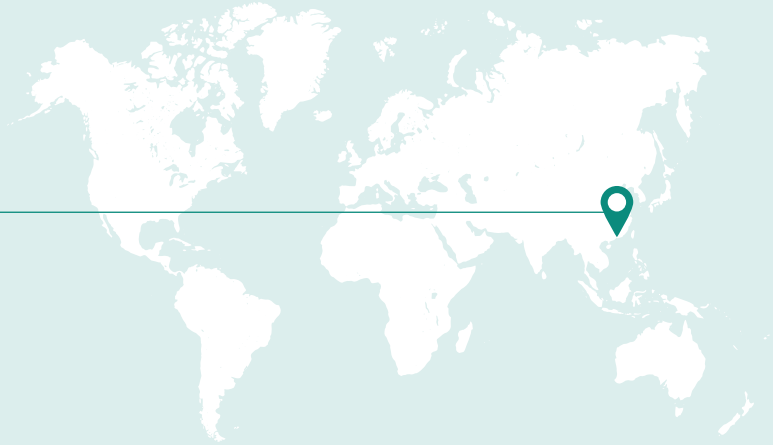
Development of the spatial land-use plan that forms part of Lamu's County Plan was supported by an international engineering consulting firm which used GIS software to incorporate aerial imagery to help identify and map zonally the various natural assets and ecosystems.

This built on work carried out by WWF Kenya which provided technical support by identifying Critical Ecologically Significant Areas (CESA), assisting with natural capital assessments, and general GIS support. The local branch of the organisation also helped build local capacity by supporting stakeholder engagement and providing communication materials for the County Spatial Plan.



Lamu County Spatial Plan

© WWF Kenya



CASE STUDY

China

WHAT

Nature-based solutions with the potential to provide multiple benefits, including contributing to coastal defence, have been proposed over a length of 18 km and land area 420,000 sqm in Shenzhen.

WHO

Public authority in Shenzhen with Arup technical support

WHY

The conventional relationship between client/enabling authority and designer is challenged. Nature-based solutions to coastal redevelopment proposed by the designer have influenced the thinking of the authorities tasked with building adaptation and increasing resilience to climate-related natural hazards.

This case study uses the example of a seawall regeneration project that employs nature-based solutions to improve coastal protection to the impacts of climate change, reclaim lost habitats and their associated ecosystems, and increase eco-tourism. The role and potential influence of the project designer demonstrates the positive impact that external actors can have on enabling authorities with regards to ecosystem services and infrastructure projects.

Spatial and ecological context

The Shenzhen Eastern Coastline Rebuild Phase III (SECR) is part of a wider ambition in the Shenzhen area of Southern China for a "Golden" coastal tourist landscape belt. Since 2008, the Shenzhen city government has been planning to rebuild six sections of coastal defences over 18 km around Dapeng New District in eastern Shenzhen, to improve resilience against the effects of climate change, including rising sea levels and storm surges.

The area has a significant number of habitats and species driven by the rapid transition in topography from mountainous inland down to the coast. Marine habitats are also highly diverse with rocky shores and sandy/silty areas attracting a rich diversity of flora and fauna. The Study Area is mainly composed of rural townships, agricultural lands, industrial developments, beach areas, and nearby conservation sites of importance, including the Coastline Protection Area (CPA) near Pengcheng Lychee Park.

Map showing the project location, Shenzen, China

The need for improved defences was highlighted by the devastating Typhoon Mangkhut that hit Southern China in 2018 destroying sections of the existing seawall. Up to 2.45 million people across Shenzhen's region of Guangzhou were displaced, and the local transport system was severely disrupted, with the metro temporarily closed and flights and train services in and out of the city cancelled.

A world-class coastal tourist resort and natural ecological protection zone has also recently been built in Dapeng New District. In line with this development, SECR aims to re-establish native marine habitats such as mangroves, coral reefs and sea grass. These habitats – and the associated ecosystem services they provide – have been depleted due to the rapid economic development and urbanisation in the region since the 1980s.

To meet the objectives of both improving coastal defences and re-establishing native habitats, the Shenzhen city government has engaged with international engineering consulting firm, Arup, to explore using nature-based solutions for SECR. Nature-based solutions protect, manage and restore natural or modified ecosystems. They may deliver benefits simultaneously to human well-being – in this case by improving coastal defence – and to the natural environment. Nature-based solutions may comprise both natural and constructed features to enhance their durability, effectiveness and suitability for their environment. This compares to conventional "hard" infrastructure such as sea walls and groynes that may provide physical protection but generally lack the capacity to support habitats and improve ecology and biodiversity.

Approach

A two-stage assessment has been carried out by the consultants to establish a baseline of existing ecosystem services across the SECR area. The assessment is based on the approach used by other similar scientific studies[18] that adopt the principles of the UN Millennium Ecosystem Assessment (MA). The MA was initiated in 2000 with the objective of "assessing the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems."[19]

The first assessment stage for SECR, Environmental Baseline, aims to identify and categorise the existing ecosystems and the services they provide. This was undertaken by:

1. Identifying the key habitat zones across each of the sites (e.g. land, beach, marine) and their main habitat types (e.g. woodland, sand, mudflat); and
2. Categorising the broad ecosystem services provided by the main habitat types.

A baseline of each existing habitat and their associated ecosystem services for each site within the project area was first characterised by assuming no implemented nature-based solutions. A corresponding post-development assessment (with implemented nature-based solutions) was then carried out. The anticipated potential change, positive or negative, between the baseline state and post development state was then made using a criteria-based scoring system.

The assessment findings are divided into the four MA ecosystem service categories:

1. Provisioning services;
2. Regulating services;
3. Cultural services; and
4. Supporting services.

After the environmental baseline was established, the second stage of the assessment, the Qualitative Baseline was then implemented. First a set of assumptions were made to show the assumed extent of nature-based solutions being made at each site. This was informed by analysis of historic habitat mapping, aerial imagery and a high-level site walkover.

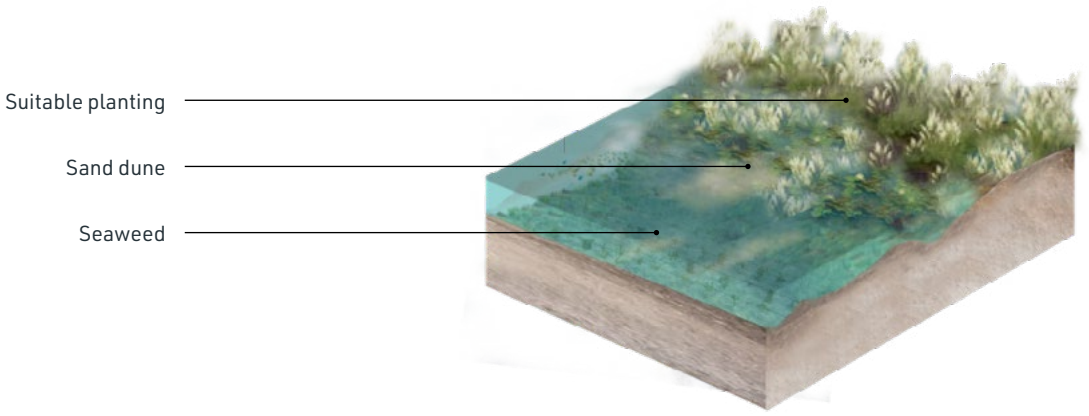
Based on these assumptions, an assessment was provided on the current (baseline) and post-development level of ecosystem services, and the extent of anticipated change due to the nature-based solutions. These are considered first holistically across the SECR site and then on a more detailed site-by-site basis, based on an understanding of the environmental requirements of the nature-based solutions and the availability of these at each of the sites.

Outcome

The approach caused the project development to pause, as the local public authority is considering alternative options taking into account the outcomes of the assessment, specifically the proposed nature-based solutions.

Planning concept

Inspired by the original landscape



Why is this interesting? Key lessons

Shenzhen city government had not previously considered using an ecosystem services approach as an assessment method mainly because, as with most places in the world, existing local planning laws do not mandate that ecosystem services are required to be considered.

The project consultants, Arup, implemented this approach to not only improve coastal defence to climate change, but to demonstrate economic benefits that nature-based solutions may realise over conventional "hard" infrastructure.

For example, these solutions complement the recently built coastal tourist resort and natural ecological protection zone in Dapeng New District supporting tourism and benefitting the local economy. Nature-based solutions are also considered highly effective at providing coastal defence and, as a result, may mitigate the future costs required to repair damage to infrastructure such as that caused by Typhoon Mangkhut.

This more holistic proposal, derived from considering ecosystem services, has meant that Shenzhen city government is now considering using nature-based solutions over conventional measures. A key outcome of this case study therefore is that project consultants have been influential in advocating with the enabling authority for a more holistic approach taken to develop the Shenzhen coastal defence beyond the conventional "hard" infrastructure typically used.

Another lesson from this case study is that delivering these proposals at an early stage in the project has meant that these solutions can be fully considered well in advance of design stages where it may otherwise be too late to adopt innovative measures.

Replicability

Technically there is the potential to establish global 'parameters' to inform choices of nature-based and climate resilient solutions for infrastructure. The designer's role of positively influencing the approach should also be recognised especially as, in many cases, the brief of infrastructure projects at the masterplan or concept stage is to a degree intended to be interpreted and improved.

Tools

The ecosystem services assessment adopted the principles of the MA. The MA is designed to provide decision-makers with information to manage ecosystems in a more sustainable manner, that will maintain both biodiversity and the ecosystem services that are essential to human well-being.

The SECR assessment considered the first three of the following five overarching questions that guide the issues being assessed by the MA:

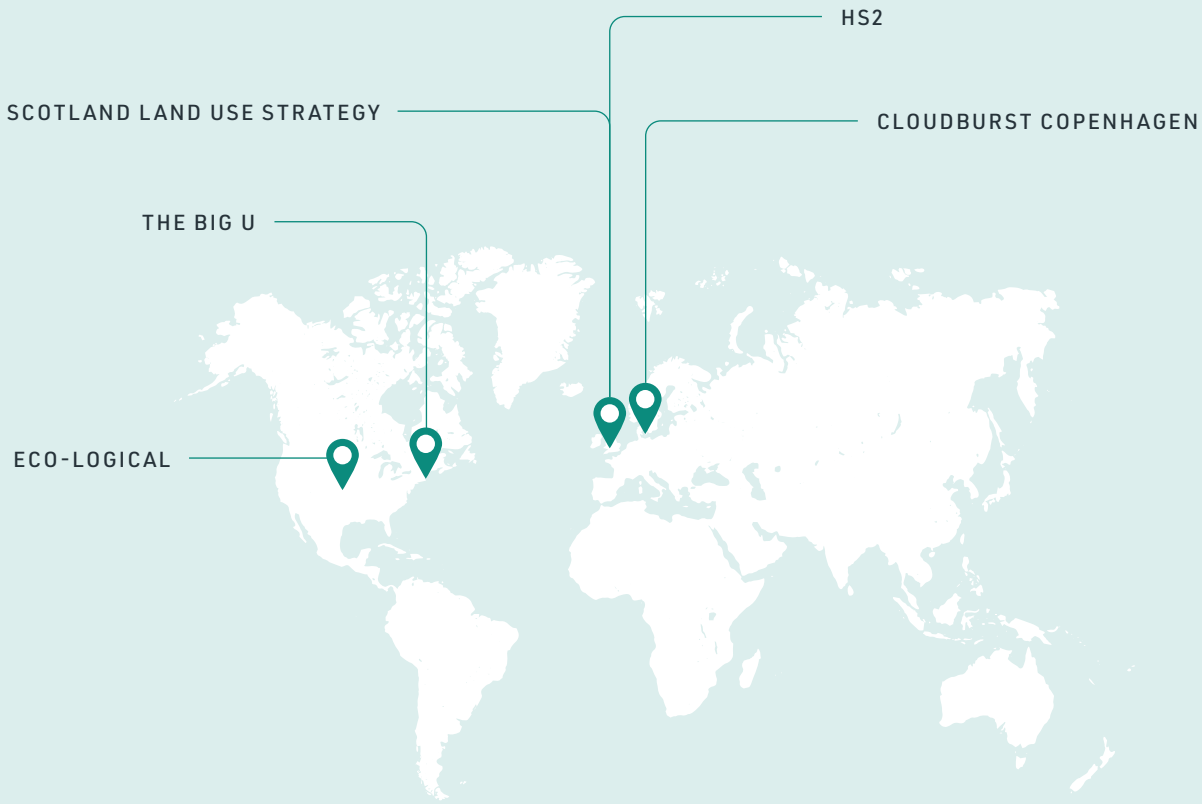
1. What are the current conditions and trends of ecosystems and their associated human well-being?
2. What are the plausible future changes in ecosystems and in the supply of, and demand for, ecosystem services and the consequent changes in health, livelihood, security, and other constituents of well-being?
3. What can we do to enhance well-being and conserve ecosystems? What are the strengths and weaknesses of response options, actions, and processes that can be considered to realise or avoid specific futures?
4. What are the most robust findings and key uncertainties that affect provision of ecosystem services (including the consequent changes in health, livelihood, and security) and other management decisions and policy formulations?
5. What tools and methodologies developed and used in the Millennium Ecosystem Assessment can strengthen capacity to assess ecosystems, the services they provide, their impacts on human well-being, and the implications of response options?

Surveys were carried out during a high-level site walkover by the consultants to help fulfil the requirements of the MA by providing a baseline of habitats and associated ecosystem services in the SECR area.

Historical maps were also consulted to determine the extent of previous habitats now lost due to development and urbanisation along the Shenzhen coast since the 1980s. Areas previously inhabited by mangroves, coral reefs and sea grass beds shown in the maps have been identified in the assessment as opportunities for nature-based solutions.

CASE STUDY

Europe and USA



Truly holistic planning that explicitly analyses ecosystem scenarios under multiple climate scenarios is yet to be found clearly in a single example. However, there are promising examples that highlight varying approaches to infrastructure planning, incorporating different elements of accounting for ecosystems services and climate change impacts. These examples still have important gaps, but they present areas of promising practice.

HS2

UNITED KINGDOM

HS2 is a planned high-speed railway covering 550 km across the UK. Opening in phases between 2026 and 2033, it will link the cities of London, Birmingham, the East Midlands, Leeds and Manchester. Although not explicitly termed "ecosystem services", these functions are assessed within EIAs for each phase of the project. They include climate change, ecology and biodiversity, land quality, waste and material resources, water resources and flood risk.

HS2 offers an excellent example of the long-term view which must be taken on large-scale infrastructure planning projects, incorporating environmental considerations across the lifetime of the project. The challenge of achieving this includes incorporating changes in thinking and practices around ecosystems services and climate change impacts as the project unfolds over several years. Environmental considerations which may have been progressive at the start of the project must be continually re-assessed to ensure they evolve with industry best practice.

Baseline conditions for each ecosystem service are established through a combination of desk study, field survey and consultation. The potential ecosystem impact area will define the survey corridor width for each of the services identified. This, in turn, depends on factors such as the engineering of the route, topography and ecological connectivity.

This dynamic approach has enabled ambitious environmental targets to be set. For example, the scheme is aiming to achieve "no net loss" in biodiversity at a route-wide level, helped, in part, by the proposal of a green corridor along the route aiming to protect and enhance wildlife habitats. Like many other similar assessments of this nature, GIS mapping data has been used to spatially identify these areas which, in the case of HS2, is available publicly to improve stakeholder engagement and consultation.

Visualisation of route options for HS2

© Arup

Eco-Logical

UNITED STATES

Eco-Logical is a framework developed by the US Federal Highways Administration (FHWA) and other government agencies to encourage federal, state, tribal, and local partners involved in infrastructure planning, design, review, and construction to use flexibility in regulatory processes.

Since 2008, the Charlottesville Albemarle Metropolitan Planning Organization (CA-MPO) and its sister organization the Thomas Jefferson Planning District Commission (PDC) have worked to implement this approach for transportation planning into PDC and CA-MPO's planning and project development activities.

The approach taken by CA-MPO and PDC using the Eco-Logical framework demonstrates the potential positive outcomes from early and consistent collaboration between planning authorities at different levels. Enabling plans which span across institutional boundaries and jurisdictions has meant that ecosystems service can be more readily evaluated, protected and enhanced through the infrastructure planning process.

The framework aims to integrate plans across agency boundaries and endorses ecosystem-based mitigation measures to address the negative impacts associated with infrastructure development.

The approach is grounded in three defining principles:

1. Integrated planning between natural resource and transportation agencies.
2. Mitigation options in the context of regional habitats and ecology that enhance the Regional Ecological Framework, a tool used as part of the assessment
3. Performance measures that balance predictability and adaptive management.

The Regional Eco-Logical Framework (REF) is a major component of the Eco-Logical process. The REF was originally developed by PDC with support from FHWA. The REF comprises GIS mapping data, and is made up of an inventory of significant natural resources that are important to the region's ecological health. This provides a baseline of the relevant ecosystem services which can then be considered alongside other issues important to a project.

Over an 18-month period beginning in September 2013, CA-MPO staff worked with a select group of local stakeholders to conduct a pilot implementation of Eco-Logical to develop transportation alternatives for alleviating vehicular congestion at US-250 Free Bridge.

Through two rounds of funding assistance, CA-MPO and PDC were able to develop and deploy a regionally focussed ecological habitat model and strengthen partnerships with state and local resource management agencies. Though carrying out a comprehensive analysis added time at the start of the project, it was ultimately completed within an overall shorter timeframe due to the early efforts to evaluate environmental impacts.

The Big U

UNITED STATES

The Big U was an opportunity for architects and designers to propose a more holistic approach to flood and storm protection, valuing eco-system services and combining many of their benefits with attractive design features. This allowed for nature-based solutions which will enhance local ecosystems services, providing significant benefit to local residents and incorporating improvements in public spaces. It is an excellent example of planning which considers ecosystems services and responds to climate change. However, implementation is only in early stages, so the final outcomes remain to be seen.

In response to hurricane Sandy, the Big U has been designed to protect the low-lying geography of Lower Manhattan from floodwater, storms, sea level rise and other expected impacts of climate change.

The full proposal includes 10 continuous miles of protection which incorporates nature-based solutions and offers multi-purpose public spaces tailored to the local neighbourhoods.

Divided into separate compartments across East River Park, Two Bridges and Chinatown, and Brooklyn Bridge to the Battery, each one provides a physically separate flood-protection zone, while also offering integrated social and community planning to protect and enhance the city.[20] The first phases of this project have been funded through a public-private partnership for the East Side Coastal Resiliency (ESCR) and Lower Manhattan Coastal Resiliency (LMCR) which align with the compartments outlined in the original proposal. Construction work is expected to begin in late 2019.

Manhattan, New York

The big U project has been designed to protect Lower Manhattan from floodwater, storms, sea level rise and other expected impacts of climate change.

Photo by Brandon Jacoby

Cloudburst Copenhagen

DENMARK

In 2011, a major flood hit the city of Copenhagen, leaving parts of the city under 1m of water, and costing 800m Euros in insurance claims. Recognising that these types of events are likely to increase due to climate change, this prompted the city of Copenhagen to produce its 'cloudburst mitigation plan' which identified the areas of the city most at risk from future cloudburst events, and proposed solutions to increase the city's resilience to flooding.

Cloudburst Copenhagen demonstrates the potential of city-level planning to create a network of blue-green infrastructure and a range of nature-based solutions which can collectively enhance ecosystems services and deliver improved climate resilience. This kind of planning at city-scale requires increased cooperation across local authorities and ambitious implementation plans in order to be successful.

The strategy focuses on retaining rainwater in the upper catchment; providing adaptable drainage in low-lying areas; and implementing green and blue solutions in existing projects. This project used a hydrological model of the sewers and watercourses alongside a digital model of the city to analyse the flow of water through the city and nearby catchment areas. Over 300 solutions were rolled out gradually across the city, including storm water roads to transport water to lakes and the harbour, green roads to detain and hold back water locally, and an increase in the capacity of traditional storm water pipes to remove excess water.

As a whole, this network of blue-green infrastructure works to mimic the natural water cycle which has been disrupted by urban development in the area, and restore ecosystems services which had previously been diminished. Many of the solutions have also been designed to have dual uses, providing inviting public spaces and increasing urban habitats and biodiversity. The creation of a network in this example shows a shift in thinking towards resilience planning at a city-level, while adapting around existing infrastructure.

Canals in Copenhagen, Denmark

Photo by Maria Bobrova

Scotland Land Use Strategy

UNITED KINGDOM

Scotland's Land Use Strategy, first published in 2011 and revised in 2016, is considered the first of its kind in Europe, taking an ecosystem approach to land use. The strategy sets out a direction of travel towards more integrated and sustainable land use across Scotland in consultation with national and local-level stakeholders.

A rare example of ecosystem services planning at a national scale, the Strategy demonstrates a holistic approach to planning which will have impacts at all levels, from national down to local projects. If given consistent support for implementation, and regularly evaluated and held to account, the Land Use Strategy has the potential to transform planning across the country

Building on the momentum of the Climate Change Act passed in 2009, the strategy recognises the importance of ecosystem services and the opportunities and threats brought about by a changing climate. As a result of the first strategy, two pilot projects were planned and implemented, one of which was the Aberdeenshire Regional Land Use Strategy which aimed to consider land use in an integrated way; guide decisions to optimise land use; and create an online tool to inform decisions about competing or conflicting land use.

As part of this, an online mapping tool was developed focusing on woodland creation in Aberdeenshire in relation to six possible policy priorities: woodland expansion; prime land protection; reducing flood risk; improving water quality; woodland and landscape character; and woodland and public access. The tool allows users to map potential policies and see how they affect ecosystem services provision.

The second strategy, in 2016, followed up on the learnings from pilot initiatives and has proposed new pilot activities in alignment with the national planning framework, particularly in urban areas.

This approach to embedding ecosystems services and climate change impacts in a cascading effect from national down to local planning is an example of the long-term commitment needed to achieve sustainable results in planning and infrastructure projects, and the potential for integrated, sustainable development when this does happen. It further demonstrates the role of governance and policy in holistic environmental planning.

Isle of Skye, Scotland, UK

© Global Warming Images

Policy Options and Frameworks

Integrating ecosystem services and climate change into infrastructure planning is a concern that development agencies, financial cooperation institutions and development banks, national governments and regional institutions are increasingly acknowledging and are trying to address. This is reflected in the development and adoption of a plethora of tools and instruments used to ensure the integration of multi-dimensional aspects when designing investments, beyond the environmental safeguard screening mechanisms.

For example, at regional and national levels, Strategic Environmental Assessments (SEA) provide an opportunity for including ecosystem services and climate change into planning decisions at the strategic level.[21] Currently, several dozen countries have either national legislative or other provisions for SEA, and Environmental Impact Assessments (EIA) offer another approach for site-specific project proposals. However, there are currently few examples of where SEAs or EIAs have integrated considerations of climate change impacts on ecosystem services into their assessments. Mainstreaming climate change into SEAs requires several actions including[22] [23]

- Building a conceptual framework for Ecosystem Services (ES) production and use in the study region, including analysis of regulations, plans and policies
- Determining priority ES and assessing their baseline conditions and trends
- Developing possible alternatives that enhance opportunities and reduce risks for ES, and assessing their impact
- Monitoring changes in the context and impacts on ES

There is also a range of policy instruments which can influence the integration of ES into infrastructure planning including economic and financial instruments, legal, regulatory and rights-based instruments, institutional aspects and socio-cultural conditions, and multi-stakeholder approaches.[24] Tools and other approaches may also be employed to support the assessment of climate change and biodiversity as part of the SEA process. Selected examples include ecosystem-based approaches, ecosystem services valuation, green infrastructure and natural capital approaches.[25]

SEAs may be led by national or local governments or alternatively undertaken in relation to a donor's own processes. Donor-backed infrastructure support facilities and programmes create procedural guarantees so that ecosystem services and their stakeholders will be taken into account in planning and execution. Some examples of successful integration of ES into donor's SEA processes include:

WHO	WHAT
IADB (INTER-AMERICAN DEVELOPMENT BANK)	Created guidance for assessing and managing biodiversity impacts and risks on ecosystem services in IADB-supported operations. The Disaster Risk Management Policy requires consideration of the interconnectedness of climate change and biodiversity.[26]
IADB (INTER-AMERICAN DEVELOPMENT BANK)	Presents a framework titled, "What Is Sustainable Infrastructure?", for the public and private sectors to support the planning, design, and financing of infrastructure that is economically, financially, socially, environmentally and institutionally sustainable. Considered a working document, it aims to generate discussion among key stakeholders and serve as a basis for research and experimentation within the IDB and with clients.
IADB (INTER-AMERICAN DEVELOPMENT BANK)	Investigates the nature and consequences of conflict in infrastructure projects in Latin America and the Caribbean (LAC) in the report "Lessons from Four Decades of Infrastructure Project-Related Conflicts in Latin America and the Caribbean". Thought to be the first study on this scale at the infrastructure industry, the analysis demonstrates that the nature of conflicts is multidimensional, and more dynamic than traditionally conceived by both firms and governments. It also establishes that conflicts materialize through the interaction of environmental, social, governance, and economic drivers over a long period. Overall, deficient planning, reduced access to resources, lack of community benefits, and lack of adequate consultation were the most prominent conflict drivers.
EBRD (EUROPEAN BANK FOR RECONSTRUCTION AND DEVELOPMENT)	Published its Environmental and Social Policy which contains a performance requirement on the conservation of biodiversity and sustainable management of natural living resources. The baseline assessment includes impacts on ecosystem services relevant to climate change and adaptation.[27]
THE WORLD BANK (WB)	Recognises SEA as a key means of integrating environmental and social considerations into policies, plans and programmes, particularly in sector decision-making and reform. The Bank is committed to promoting the use of SEA as a tool for sustainable development[28]. Its report, "Strategic Environmental Assessment in the World Bank"[29] highlights the considerable knowledge generation that informed national and regional approaches to planning and policy-making, including mainstreaming climate change strategies at a national level. It also highlights limitations as to why SEA is not used more frequently.

WHO	WHAT
THE WORLD BANK (WB)	Published the report "Lifelines: The Resilient Infrastructure Opportunity"[30] which makes an economic case for building more resilient infrastructure. According to this report, the net benefit on average of investing in more resilient infrastructure in low- and middle-income countries would be $4.2 trillion, with $4 benefit for each $1 invested. The report presents a series of recommendations which include creating financial incentives for service providers to promote resilient infrastructure services, including payment-for-ecosystem-services (PES) schemes, which promote the use of nature-based solutions to increase resilience of the full infrastructure service. Moving from resilient assets to resilient infrastructure services provides a systemic view of the resilience of the full system, including supporting systems such as ecosystems and wider river basins. The report also highlights a lack of incentives to protect or restore ecosystems as one of the obstacles to infrastructure resilience.
THE WORLD BANK	Published a decision tree framework for confronting climate uncertainty in water resources planning and project design[31]. This tool provides a clear method for demonstrating the robustness of a project to climate change, and helps to identify projects that perform well across a wide range of potential future climate conditions. The tool first screens for climate vulnerabilities, and a 'decision tree' subsequently helps project teams assess, and then develop plans, to manage climate and other risks. What makes this innovative is its step-by-step design—similar to a tree on which each "branch" builds off the previous one. Further or deeper analysis is performed only as needed, which helps decision makers allocate scarce project resources in a way that is proportional to project needs.
ADB (ASIAN DEVELOPMENT BANK)	ADB is committed to supporting the shift towards a low Greenhouse Gas (GHG) emissions and climate-resilient development path[32]. As stated in ADB's Climate Change Operational Framework 2017-2030[33], ADB will support its developing member countries with approaches to strengthening climate resilience across built infrastructure and ecosystems, and at the community level. Furthermore, ADB will also go beyond simply ensuring that the infrastructure it finances is climate-proof and prioritize projects specifically targeted at climate adaptation. The framework includes an implementation plan which indicates that Country Partnership Strategies and Country Operations Business Plans will be based on solid diagnostics of climate risks, adaptation and mitigation priorities and objectives, and available capacity for climate action. ADB's assistance will be targeted accordingly.

WHO	WHAT
ADB (ASIAN DEVELOPMENT BANK)	In its Strategy 2030[34], ADB states that infrastructure investments – particularly those that are green, sustainable, inclusive, and resilient – will remain a key priority, with their operational priorities including tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability[35]. This can include promoting smart and green infrastructure planning and design, integrating biodiversity; resource use efficiency, including sustainable sourcing of materials across supply chains; improved energy and water efficiency; and pollution management. Efforts to support the integration of biodiversity and ecosystem services will be focused on linear infrastructure such as roads and railways, renewable energy and transmission and distribution lines; biodiversity in agriculture landscapes; and environmental flows in hydropower projects. ADB will ensure that biodiversity is fully protected, and that pollution impacts and risks are addressed by conducting assessments and integrating practical solutions in project design and implementation.
GIZ (DEUTSCHE GESELLSCHAFT FUR INTERNATIONALE ZUSAMMENARBEIT)	Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) has supported programmes in India performing economic assessment of ecosystem services and providing policy-specific recommendations at national, state and local levels to foster sustainable development and better conservation of ecosystems and biodiversity[36]. On a separate project, GIZ has assessed methods for integrating ecosystem services into policy, planning and practice globally[37]. Another GIZ project has transposed the international framework of action of the Global Framework for Climate Services (GFCS) to national level in its partner countries[38]. It promotes the country-specific institutional and technical design of structures to enable countries to make better use of climate services and to include them in their infrastructure planning.
GIZ (DEUTSCHE GESELLSCHAFT FUR INTERNATIONALE ZUSAMMENARBEIT)	GIZ has published a Climate Risk Assessment for Ecosystem-based Adaptation Guidebook which provides a standardised approach to climate risk assessments in the context of Ecosystem-based Adaptation (EbA) planning by following the well-established, modular Sourcebook (GIZ 2014) methodology, and using an illustrative application example[39].

These examples of policies, frameworks, tools and approaches extracted from publicly available documents demonstrate how, globally, infrastructure finance and assistance institutions are moving towards more integrated holistic approaches to anticipate and mitigate the impact on ecosystem services in the context of climate change.

While these trends are positive and promising, this review also unveils a complex and varying landscape of approaches, meanings and tools, which do not help to simplify and streamline the global shift required for developing sustainable infrastructure development at scale.

Key Findings

Each of the above case studies was selected based on the criteria agreed at the beginning of the project. From the outset, it was important to ensure a spread of examples across the world and, given the difficulty in finding case studies which scored highly across each criterion, these examples were chosen to represent different positive aspects of infrastructure planning.

When analysing these case studies, several different aspects were considered: the overall enabling conditions; the different approaches taken; the planning and financial aspects; and the potential for replication. Analysis of these case studies highlights a series of key findings, organised in four main areas, with considerations of replicability and appended action-points.

HOLISTIC APPROACH TO SUSTAINABLE INFRASTRUCTURE DEVELOPMENT AT SCALE: AN EMERGING TREND, YET TO MATURE

The initial research brief was designed to focus on selected examples from around the world that would showcase best practice in infrastructure planning, and which has integrated ecosystem services and climate change throughout the infrastructure development cycle at scale. All case studies attempted to integrate long-term considerations on ecosystem services, although not all of them also incorporated climate change impacts into their processes, and this remains a critical gap.

A more holistic integration of ecosystem services – and the projected effects of climate change on both extremes and natural processes – in the planning, design, implementation and operation of infrastructure at scale is an emerging trend. Tools exist, awareness is increasing, and policies are evolving. Also, the rapid review of the publicly available environmental, planning and investment-design policies and frameworks from funding agencies and institutions seems to confirm. The effectiveness of these frameworks was not reviewed by this study, but there is a clear interest in better understanding the complex interplay of infrastructure on the socio-ecological environment in the context of climate change effects.

It is possible that this thrust towards more holistic approaches is driven by the Sustainable Development Goals and the Paris Agreement processes, although this research cannot confirm such attribution. That said, greater awareness of the effects of climate change is certainly causing separate disciplines to converge, and forcing stakeholders from the private and public sector to re-examine their respective scopes.

However, there continue to be challenges, including territorial scale, finance, timeframes and procurement processes,

and these approaches are yet to mature in a globally coherent shift in approach. In particular, there are key limitations linked to the time involved in the development cycle of large infrastructure, and the sheer territorial scale of projects.

While several excellent examples exist, there is less evidence to document how this strategic level translates into projects on the ground. The example of Scotland's Land Use Strategy is illuminating here: it is novel in its scope, but without consistent political commitment and support for implementation, eight years on it is still difficult to find concrete examples of specific project outcomes. It is possible that tracking outcomes of strategies over the long-term is difficult. But it is also likely that strategic approaches are diluted when faced with the reality of implementation, finance and the changing political agendas that are normal over a longer period of time. The spatial coverage of projects also requires the co-operation of multiple administrative layers, and this too may affect the practicalities of implementing the strategy.

Finally, a more integrated approach also requires cutting across disciplines and specialisms. A standardisation of language may not be required, but to be effective, a more precise language that engage specialisms across disciplines will be needed.

ACTION POINTS FOR ADVOCACY

There is a substantial amount of work to be done at the global level to clarify scope, language, and approaches across all phases of the planning cycle for large-scale, multi-year infrastructure. This needs to start from the strategic planning, and continue through the physical planning and quantitative assessments for design, to implementation, and ultimately operation and maintenance. Frameworks and cases reviewed demonstrate how global actors, governments and designers are beginning to overcome disciplinary boundaries and respective methods to deliver sustainable infrastructure.

Specific actions could include:

- documenting in detail the effective approaches described in this report
- launching a global call for examples
- engaging major financial institutions, regional bodies, countries and industry to develop a more coherent policy approach and to update processes, policies and tools
- developing a language for advocacy that is adequate and resonates with that of different disciplines involved.

This should be carried out under the auspices of a global platform such as the UN, with dedicated funds, and included in global agendas for the implementation of the Paris Agreement.

DECISION-MAKING FOR ADOPTING, AND SUSTAINING, INTEGRATED APPROACHES OVER-TIME

The review of the case studies demonstrates that a plethora of decision-making frameworks, monitoring and screening tools exist. These aim at facilitating the design of projects that integrate ecosystem services and climate change implications.

Case studies and the broader review suggest that these decision-making tools tend to work more effectively when used in contexts with a progressive policy and institutional environment. This creates an enabling environment for decision-making over time and across administrative boundaries and sectors. In practice this tends to also be found where decisions are taken based on technical evidence, following sustainable policies, and are enforced at all levels.

In cases where there are progressive legal systems which encourage more in-depth analysis of environmental impacts, there does seem to be evidence of a positive effect on infrastructure planning. In the example of the LAPSSET corridor in Kenya, part of its success is due to national legislation requiring county-level environmental assessments, and the ability of different actors to seize this opportunity to promote a sustainable approach to planning and development.

However, the integration of ecosystem and climate change assessments in the same frameworks is still in its infancy, and there are technical, temporal, administrative and financial complexities to address. All case studies dealt with complexity successfully, but differently. It is likely that to be effective, some capacity building may be necessary in the short-term, to ensure these assessments are appropriately considered rather than becoming a tokenistic activity, and to ensure that the combined effects of climate change on ecosystem services are fully analysed.

The China example showed how the designer first used high-level assessments with different scenarios to influence the outcome early in the process, leading the decision-maker to consider different options, which will hopefully lead to the design and implementation nature-based solutions. This case study demonstrated the critical role of industry – in this case represented by the designer – to help decision-makers in taking evidence-based decisions in infrastructure development.

In Mexico, the challenges of making decisions and sustaining them across multiple administrative layers were addressed through strong relationships between key stakeholders, engaged over long periods of time, and a precedent of working at the catchment level through basin councils. This case study also shows the effectiveness that frameworks by development institutions, in this case the World Bank, may have to help authorities in ensuring that changing climate and ecosystem viability is considered in future infrastructure investments. The work was further supported by an innovative decision support tool which could compare different infrastructure options and their robustness under multiple climate futures.

In Kenya, the actors managed to seize the opportunity of County Planning as oriented by the Constitution to substantially influence the ultimate infrastructure planning and design. The case study

highlights how a positive outcome can be borne from collaboration of stakeholders including planning authorities, international NGOs, international design firms and finance parties.

Despite positive progress towards integrated decision-making supported by evidence across multiple areas, and the different strategies applied to deal with the interplay of factors, the review also identified bottlenecks in effective decision-making. One of them seems to be the use of ecosystem and climate change assessment too late in the process, at a point in which they can no longer influence the design of infrastructure significantly. The timing of the socio-ecological assessments, and consideration of climate change projections, in the Shenzhen sea wall case study demonstrates the positive results of critically timed intervention. In this example, the local authority considered the effects on ecosystem services at a point when the project still had enough flexibility to consider alternative, nature-based solutions which would reduce environmental impacts.

ACTION POINTS FOR ADVOCACY

There is an opportunity to shape the convergence of different approaches and frameworks in order to standardise them across institutions, and simplify complex planning considerations for practitioners. Any work in this area would need the full support and buy-in of international institutions and therefore would need to be led by a credible organisation or coalition. If successful, it could influence the design and construction industry to incorporate these assessments as standard practice. While most major funding institutions have already produced various policies on the environmental impacts of their projects, embedding ecosystem services assessments at the beginning of major infrastructure projects as standard would provide a clear signal to the industry, and would likely lead to a rapid change in standard planning processes.

Similarly, there is an opportunity for advocacy to alert all stakeholders involved to understand the critical aspects of the project life-cycle, and when holistic approaches are more likely to be influential.

A review of global standards and frameworks for decision-making and investment design could advance the agenda. This could be promoted under parent global processes, such as the Sustainable Development Goals, Paris Agreement, or Convention on Biological Diversity among others, and led by the United Nations Sustainable Development Group (UNSDG). The design and construction industry would likely follow and contribute actively.

TECHNICAL SOLUTIONS: SHARING THE TOOLBOXES ACROSS DISCIPLINES AND STAKEHOLDERS

When analysing the case studies presented above, specific focus was given to the tools used in each case, both to understand emerging approaches and to assess the potential for replication.

The examples show that financial institutions, local government authorities and planning practitioners have access to adequately sophisticated tools and many of these can be tailored to the context. Indeed, there is recognition that some of these tools could be effectively applied elsewhere, and several examples of initiatives to share approaches and tools were found – for example, the World Bank's knowledge repository, or the Eco-Logical tool being scaled up in the USA. The toolboxes of the different disciplines contain many relevant tools and methods that can support ecosystem and climate-change-responsive planning, design and implementation of infrastructure.

The involvement of academia and technical specialists was a trend throughout these case studies, which suggests that without adequate financing, it may not be possible to replicate the successes shown in the examples. However, it is promising that there are a number of researchers and technical organisations developing tools and approaches in this area. With time, and with sufficient demand, many of these tools could be further simplified and shared to increase their reach.

However, challenges still exist, including the standardisation and quality of the methods; access to finance to obtain the services of skilled professionals; and ensuring that procurement processes lead to the hiring or appropriate specialists. Standardisation – of at least a critical review of approaches – would simplify the challenge of incorporating these issues into infrastructure planning and reduce the likelihood of variance in the quality of assessments. It would also systematically require the industry to deliver services across these fields and enable authorities to monitor the quality and extent of the services.

Procurement processes are often fragmented, with specialists contracted for short-term assignments within the larger projects, without specific requirements to share tools developed, and with consequent 'projectisation' of the approaches, or fragmentation of their deliveries within the same project. A holistic approach to the life-cycle of the infrastructure across themes as complex as ecology and climate change, should require procurement to adapt: this means including these topics fully in tender notes, procurement processes, budgets, and, ultimately recruitment and management. Finance is naturally one of the main challenges to ensure appropriate technical skills are made available. Advocacy must make efforts to prove that costs for planning and designing sustainable infrastructure with holistic approaches, are amply justified over the mid to long-term.

ACTION POINTS FOR ADVOCACY

Beyond individual knowledge banks maintained by institutions, there is potential for more sharing of tools and approaches which, once refined and accepted by practitioners, can be standardised through formal codes

and practices. The recent publication of the International Organisation for Standardization (ISO) standards for climate change adaptation is a promising sign in this sense. There are sufficient source-books, frameworks, tools and methods across disciplines (ecology, finance, engineering, planning, architecture, climate science) that can serve the development of more integrated approaches. Advocacy could focus on mobilising the industry, academia, financial and cooperation entities in sharing tools and practices

Similarly, advocacy should focus on engaging the industry, planning authorities and financial authorities to improve procurement processes, with the integration of holistic approaches into briefs, tenders, bidding documents. Failing to address these aspects hampers the ability to unlock creative and technical capacity to influence the industry.

Finally, advocacy should also create business cases with planning authorities, financial institutions, and developers to demonstrate that engaging good design services, across the life-cycle of infrastructure projects is a long-term investment. This would need to recognise the financial value, as well as social and environmental value.

LEARNING FROM COMPLEX STAKEHOLDER INTERACTIONS AND REPLICATING GOOD PRACTICES

Each of the case study examples demonstrates the important of strong stakeholder relationships which are often made more complex by the holistic approaches, and which may not correlate directly with lines of responsibility or governing boundaries. When operating at a large scale, particularly at regional, water catchment or even international level, the coordination and commitment between all stakeholders involved is critical.

Successful cases all demonstrated the ability of government bodies to work across administrative boundaries, or even across borders, as in the case of Kenya. The commitment to a holistic view of infrastructure planning, that focuses on long-term sustainability and resilience of the ecosystem and population in the face of climate change, is essential. This is even more important as projects extend over multiple years, extended areas, and multiple financial mechanisms. The example in Mexico City's water systems demonstrate that local authorities can support the adoption of more holistic approaches. In that case, the basin councils had already set a precedent for planning at catchment level, which became an entry point for the project.

There is also a clear role for designers and practitioners to play in influencing the 'clients' who are funding or implementing infrastructure projects. In the case of the Shenzhen sea wall, a strong relationship with the local authority, and the willingness of designers to propose ideas beyond the initial brief, resulted in a step towards stronger ecosystem resilience and greater consideration of climate change in the project.

Strong stakeholder relationships are difficult to replicate in that they are context specific, heavily influenced by the overall regulatory and institutional environment, and dependent on the nature of the stakeholders involved.

Promising case studies demonstrated evidence of committed stakeholders who were technically skilled and able to show leadership.

It would be possible to study and document how the industry, institutional and financial landscape interacts successfully, and identify the mechanisms that enable positive relations. Based on this it would then be feasible to outline expected roles, responsibilities and behaviours required for the development and consistent use of integrated approaches.

ACTION POINTS FOR ADVOCACY

Learning from successful interactions is key in order to document mechanisms, roles and behaviour that are effective in a variety of contexts. Advocacy could focus on seeking further successful case studies, and asking a variety of actors how to address challenges in stakeholder interaction.

Conclusions

This initial review highlights promising trends at global level, across regions, towards a more holistic approach to integrate ecosystem services and climate change effects. The entire landscape of actors involved in infrastructure development seems to acknowledge the need to develop infrastructure in a different manner. Countries and cities are called upon to reconcile the expected growth in infrastructure with the evidence that planet boundaries have now been reached, while climate change affects people, economies and society. There are promising practices, which demonstrate that committed institutional, financial and technical stakeholders can comprehend the complexity, and can plan and design more sustainable projects at a large scale.

This evidence base, however, is small and there is there is the risk of 'too little, too late' in this shift towards more sustainable infrastructure. The challenges remain for them to resolve trade-offs, reconcile values, and establish the acceptable balance between fast-paced development and ecological viability in the context of climate change. In doing so, they still face a lack of readily available technical capacity to support decision-making; insufficient financial investment to implement good technical solutions; and often weak governance systems that do not allow strategic decisions to survive multi-year project cycles.

A 'best-in-class' example remains elusive, highlighting the persistent gap in fully holistic infrastructure planning. The initial evidence gathered here, however, should be used to advocate with financial institutions, multi-lateral and bilateral institutions, and industry associations around the world, to increase the pace in integrating environmental and climate approaches throughout the entire cycle of infrastructure projects.

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Annex A - Criteria for the selection of case-studies

Definition / Score	0	1	2	3
Scale	The plan/project is within a planning framework or project pipeline at the local/ city/ municipal scale.	The plan/project is within a planning framework or project pipeline at the district/ regional scale.	The plan/project is within a planning framework or project pipeline at the national scale.	The plan/project is within a planning framework or project pipeline at the international scale.
Investment and/ or spatial planning processes	In case of regional plan and/or master-plan, it did not lead to the planning of any sustainable infrastructure projects, or the project appraisal and planning processes were not informed by a broader regional strategic plan.	In case of regional plan and/or master-plan, it has led to planning of one or more sustainable infrastructure projects, but construction has not started, or the project appraisal process was not informed by a regional strategic plan, altough its planning process may have considered it.	In case of regional plan and/or master-plan, it has led to planning of a pipeline of sustainable infrastructure projects, and construction of one or more projects, or the project appraisal was informed by (but not a direct result of) the regional strategic plan.	In case of regional plan and/or master-plan, it has led to planning, construction and operation of a pipeline of sustainable infrastructure projects, or the project resulted directly from the regional strategic plan.
Ecosystem services baseline assessment	There has been negligible consideration and valuation of provisioning services (e.g. food products, biological raw materials), regulatory services (e.g. air quality regulation, climate regulation), cultural services (e.g. recreation and ecotourism, ethical and spiritual values) and supporting services (e.g. biodiversity, water cycling, nutrient cycling).	There has been some consideration and valuation of provisioning services (e.g. food products, biological raw materials), regulatory services (e.g. air quality regulation, climate regulation), cultural services (e.g. recreation and ecotourism, ethical and spiritual values) and supporting services (e.g. biodiversity, water cycling, nutrient cycling).	There has been significant consideration and valuation of provisioning services (e.g. food products, biological raw materials), regulatory services (e.g. air quality regulation, climate regulation), cultural services (e.g. recreation and ecotourism, ethical and spiritual values) and supporting services (e.g. biodiversity, water cycling, nutrient cycling).	There has been extensive consideration and valuation of provisioning services (e.g. food products, biological raw materials), regulatory services (e.g. air quality regulation, climate regulation), cultural services (e.g. recreation and ecotourism, ethical and spiritual values) and supporting services (e.g. biodiversity, water cycling, nutrient cycling).
Climate change risk assessment	There has been negligible consideration of climate change impacts and risks through a Strategic Environmental Assessment (SEA), Environmental Impact Assessment (EIA), Climate Change Risk and Vulnerability Assessment, Disaster Risk Assessment (DRA), Climate Change Adaptation Strategy, or other tools.	There has been some consideration of climate change impacts and risks with the identification of the impact of each climate hazard on critical infrastructure sectors/ assets, but the assessment did not consider the impact of climate hazards on ecosystem services and related vulnerabilities.	There has been significant consideration of climate change impacts and risks with the identification of the impact of each climate hazard on critical infrastructure sectors/assets and on several types (but not all) of ecosystem services and related vulnerabilities.	There has been consideration of climate change impacts and risks on ecosystems and ecosystem services in an integrated ecosystem and climate analysis, with the identification of the impact of each climate hazard on critical infrastructure and on the four types of ecosystem services and related vulnerabilities.
Non-climatic risk assessment	There has been negligible consideration of non-climatic stressors (e.g. natural hazards, deforestation, infrastructure) on ecosystems and ecosystem services in an integrated sustainability assessment.	There has been some consideration of non-climatic stressors (e.g. natural hazards, deforestation, infrastructure) on ecosystems and ecosystem services in an integrated sustainability assessment.	There has been significant consideration of non-climatic stressors (e.g. natural hazards, deforestation, infrastructure) on ecosystems and ecosystem services in an integrated sustainability assessment.	There has been extensive consideration of non-climatic stressors (e.g. natural hazards, deforestation, infrastructure) on ecosystems and ecosystem services in an integrated sustainability assessment.
Impact on ecosystem services	There is negligible impact on the environment and ecosystems (and associated ecosystem regulatory, provisioning, supporting and cultural services).	There is some impact on the environment and ecosystems (and associated ecosystem regulatory, provisioning, supporting and cultural services).	There is significant impact on the environment and ecosystems (and associated ecosystem regulatory, provisioning, supporting and cultural services).	There is extensive impact on the environment and ecosystems (and associated ecosystem regulatory, provisioning, supporting and cultural services).
Vulnerability to climate change	The receiving ecosystems (and associated ecosystem regulatory, provisioning, supporting and cultural services) have negligible vulnerability to climate change.	The receiving ecosystems (and associated ecosystem regulatory, provisioning, supporting and cultural services) have low vulnerability to climate change.	The receiving ecosystems (and associated ecosystem regulatory, provisioning, supporting and cultural services) are somewhat vulnerable to climate change.	The receiving ecosystems (and associated ecosystem regulatory, provisioning, supporting and cultural services) are extremely vulnerable to climate change.
Innovative solutions	There has been limited innovative ecosystem-based adaptation, disaster risk reduction and sustainable solutions integrated into the plan/ programme/project design to mitigate the impact on ecosystems and ecosystem services.	There has been some innovative ecosystem-based adaptation, disaster risk and sustainable solutions integrated into the plan/programme/ project design to mitigate the impact on ecosystems and ecosystem services.	There has been significant innovative ecosystem-based adaptation, disaster risk and sustainable solutions integrated into the plan/programme/project design to mitigate the impact on ecosystems and ecosystem services.	There has been extensive innovative ecosystem-based adaptation, disaster risk and sustainable solutions integrated into the plan/programme/project design to mitigate the impact on ecosystems and ecosystem services.
Planning enabling environment	There have been limited strengths or overcoming of challenges in the cross-sector reform of the enabling environment (institutional, legal, regulatory, financial).	There have been some strengths or overcoming of challenges in the cross-sector reform of the enabling environment (institutional, legal, regulatory, financial).	There have been significant strengths or overcoming of challenges in the cross-sector reform of the enabling environment (institutional, legal, regulatory, financial).	There have been extensive strengths or overcoming of challenges in the cross-sector reform of the enabling environment (institutional, legal, regulatory, financial).
Sustainable finance	The finance appraisal process has considered environmental, social and governance criteria to a limited extent, below minimum required by ESG standards.	The finance appraisal process has considered environmental, social and governance criteria to some extent, but not beyond ESG standards, ie climate risks and ecosystme services over future time scales.	The finance appraisal process has significantly considered environmental, social and governance criteria, somewhat beyond minimum required by ESG standards, ie climate risks and ecosystme services over future time scales.	The finance appraisal process has extensively considered environmental, social and governance criteria, beyond minimum required by ESG standards, ie climate risks and ecosystme services over future time scales.
Monitoring and reporting	There has been or there are plans for limited monitoring and reporting on the valuation of improvement to ecosystems and ecosystem services resulting from the implementation of the plan/project.	There has been or there are plans for internal monitoring and reporting on the valuation of improvement to ecosystems and ecosystem services resulting from the implementation of the plan/project.	There has been or there are plans for publicly disclosed monitoring and reporting at least every 5 years on the valuation of improvement to ecosystems and ecosystem services resulting from the implementation of the plan/ project.	There has been or there are plans for annual and publicly disclosed monitoring and reporting on the valuation of improvement to ecosystems and ecosystem services resulting from the implementation of the plan/project.