EUROPEAN
COMMISSION

Brussels, 18.7.2019
SWD(2019) 305 final

PART 3/3

COMMISSION STAFF WORKING DOCUMENT

EU guidance on integrating ecosystems and their services into decision-making

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A. INSTRUMENTS AND TOOLS TO SUPPORT THE INTEGRATION OF ECOSYSTEMS AND THEIR SERVICES INTO DECISION-MAKING

There is a range of policy instruments and tools available to assist decision-makers in the integration of ecosystems and their services into policy and planning decisions. This section provides links to some key instruments and resources on their use in practice.

The links in this annex are divided into three different types of instruments available: information, decision-support and implementation, including monitoring and evaluation.

Information instruments are used to *gather and provide information* on the status of — and trends in — ecosystems and their services. This information includes both the biophysical state of ecosystems and their services, and the socioeconomic benefits these services create. Information instruments are directly used in policy formulation, monitoring and reporting. In addition, they play a key indirect role in decision-making and policy evaluation. Examples of information instruments are: (i) indicators for assessing the status and value of ecosystems and ecosystem services, (ii) databases and frameworks for monitoring, mapping and accounting, and (iii) a range of science-policy assessments, review frameworks, and procedures to support policy development and/or monitoring.

Ecosystem service mapping and assessment following the EU MEAS framework is the key information tool for ecosystem services integration. It provides a coherent framework within which a range of individual information tools can be used, such as the identification of indicators, use of databases and policy assessments or scenarios to support the different stages of the integration process. Links to guidance on information instruments are presented in Section A.1 below.

Decision-support frameworks and instruments *guide the decision-making process and convey and analyse information* on ecosystem services to support decision-making. They are also used at the end of a policy cycle, when evaluating the success of a policy and deciding how it should be revised. They include a range of instruments for planning, targeting and reporting on policies, as well as procedures and frameworks for assessing impacts and possible risks (e.g. ex-ante and ex-post assessments). Such instruments exist for decision-making in both the public and private domains. Links to guidance on decision support instruments are presented in Section A.2 below.

Implementation instruments *put into practice the information and understanding on ecosystem services*, forming the basis for concrete action on the ground. Implementation instruments can include (i) legislative instruments, (ii) spatially explicit instruments (designation of protected areas such as Natura 2000 sites, national/local zoning and land-use plans, green infrastructure plans etc.), and (iii) market-based policy instruments. Legislative instruments include EU, national and local regulations and decisions, e.g. any dedicated provisions for ecosystem condition and/or services. There is also a range of sector-specific instruments in place to allocate financing from public budgets for policy implementation. An increasing number of market-based instruments can be used to support integration. These market-based instruments include payments for ecosystem services (PES); certification and procurement schemes; and offsetting schemes. Links to guidance on these tools are presented in Section A.3 of this annex.

Monitoring and evaluation instruments are applied to assess the implementation, effectiveness and impacts of decisions, and can support adaptive decision-making as well as policy review. Links to guidance on these tools are presented in Section A.4 below.

Use of the tools presented in this section should be supported by **cross-cutting actions for awareness raising, capacity building and stakeholder consultation.** Cross-cutting actions of this sort provide ecosystem-service-related information to the process, while also promoting acceptance and use of this information. For example, information instruments require inputs from a range of stakeholders from local actors (e.g. monitoring) to regional and national institutions (e.g. data collation and analysis). Links to guidance on these tools are discussed in Section A.5.

Different instruments can be interlinked, playing dedicated roles in the integration process at different levels of EU governance. Different tools need to be used together to achieve successful integration. There are hierarchical interlinkages and interdependencies between different instruments, reflecting the characteristics of decision-making at the different levels of governance.

A.1 INFORMATION INSTRUMENTS FOR POLICY FORMULATION

Instrument category and type	Key resources and references
Information instruments: data, indicators, monitoring, mapping, accounting	
Indicators for the mapping and assessment of ecosystems and their services (including proxy indicators and benefit transfer)	**The EU Mapping and assessment of ecosystems and their services (MAES) initiative: provides a common methodological framework.** MAES resources are available on the Biodiversity Information System for Europe (BISE) https://biodiversity.europa.eu/maes (including indicative lists of ecosystem services per ecosystem type, country progress and topic pages). MAES 1st report (2013): provides a common analytical framework and typologies of ecosystems and ecosystem services. MAES 2nd report (2014): puts forward an initial set of indicators at EU and Member-State levels to map and assess ecosystem condition and ecosystem services. MAES 3rd report (2016): stock-taking of available information to map and assess the condition of Europe's ecosystems. MAES 4th report (2016): mapping and assessment of urban ecosystems and their services. MAES 5th report (2018): integrated analytical framework and indicators for mapping and assessing the condition of ecosystems in the EU.
	ESMERALDA MAES Explorer: online guidance tool on process and tools for mapping and assessment of ecosystems and their services, developed by an FP7 research project in support of MAES: http://www.maes-explorer.eu/

	Mapping ecosystem services: Burkhard B, Maes J (Eds.) (2017) Pensoft Publishers (Open Access content)
	EU Mapping and Assessment of Ecosystems and their Services – Soil ecosystems (Deltares Report, 2018), in support of the implementation of the EU Soil Thematic Strategy
	Indicators for mapping ecosystem services – a review (JRC 2012) Measuring Nature's Benefits - A Preliminary Roadmap for Improving Ecosystem Service Indicators (World Resource Institute 2009) Assessment Report on Biodiversity and Ecosystem Services for Europe and Central Asia (IPBES 2018)
	Ecosystem Services Assessment Support Tool: breaks down the ecosystem service assessment process into a logical sequence of steps. http://www.guidetoes.eu/.
Valuation tools	KIP-INCA – Knowledge Innovation Project on Natural Capital Accounting National accounting frameworks Guidance Manual for TEEB Country Studies (TEEB 2013) Review of valuation methods applied in 27 case studies by the EU Horizon 2020 OpenNESS project.
Natural capital frameworks for the business sector	UK Natural Capital Committee guidance handbook (UK NCC 2017) Natural Capital Protocol Toolkit (WBCSD) Corporate Ecosystem Service Review (WBCSD 2012) Corporate Ecosystem Service Valuation (WBCSD 2011) Cement Sustainability Initiative (WBCSD)
Research projects and knowledge platforms	OPPLA knowledge platform and marketplace - for knowledge and experience on ecosystems and their services, natural capital and nature-based solutions EU research projects - OPERAs and OpenNESS BiodivERsA – a network promoting pan-European research on biodiversity and ecosystem services TEEB knowledge platform VALUES database – provides access to global experiences and methods for integrating ecosystems and their services into policy, planning, and practice Ecosystem Services Partnership – providing a range of guidance documents and case studies
Data sources and databases	Member States reporting under the Habitats Directive Member States reporting under the Birds Directive Member States reporting under the Water Framework Directive Member States reporting under the Marine Strategy Framework Directive

	Natura 2000 viewer (EEA) Databases from Member States reporting to the Commission in other sectors, including agriculture and forestry and marine and fisheries
	EEA Biodiversity Data Centre: Monitoring data on biodiversity, environmental and pressure parameters: https://www.eea.europa.eu/themes/biodiversity/dc
	Biodiversity Information System for Europe (BISE): https://biodiversity.europa.eu/
	Targeted field observations and data collection protocols
	EU MAES and INCA data collections can inform initial screening of ecosystems and their services. Copernicus land monitoring maps or Bathymetry[1] can be used in combination with EEA 'translation' such as correspondence between Corine land cover classes and ecosystem types; a crosswalk between European marine habitat typologies; and linkages of habitats/species to ecosystems.
	EU MAES and INCA data collections can inform initial screening of ecosystems and their services. Copernicus land monitoring maps or Bathymetry[2] can be used in combination with EEA 'translation' such as correspondence between Corine land cover classes and ecosystem types; a crosswalk between European marine habitat typologies; and linkages of habitats/species to ecosystems.
	Land use maps such as Copernicus land monitoring: https://land.copernicus.eu/ **(+ historical maps if available locally to detect trends or inform restoration)**
(Spatial) modelling tools	Modelling Artificial Intelligence for Ecosystem Services – ARIES (Villa et al. 2014) OPAL: Offset Portfolio Analyser and Locator ARIES (Artificial Intelligence for Ecosystem Services) Co$ting Nature v.3 (Mulligan, 2015) Integrated Valuation of Ecosystem Services and Trade-offs 3.4.2 – InVEST (Sharp et al., 2018) Social Values for Ecosystem Services – SolVES (Sherrouse et al., 2011) Multiscale Integrated Models of Ecosystem Services – MIMES (Boumans et al., 2015) WaterWorld v.2 (Mulligan, 2015) ESTIMAP, a set of spatially-explicit models each of which can be

1 http://www.emodnet-bathymetry.eu/ see also http://www.emodnet.eu/seabed-habitats
2 http://www.emodnet-bathymetry.eu/ see also http://www.emodnet.eu/seabed-habitats

	run separately for the assessment of different ecosystem services at the European or regional scale, for use within a GIS. Currently there are eight models for assessing air quality regulation, protection from soil erosion, coastal protection, water retention, pollination, habitats for breeding birds, recreation and cultural services, and the richness of birds that are pest regulators. The models are linked to LUISA, the JRC's land-use modelling platform, enabling analysis of land use change scenarios. Although developed at the European level, the models can be downscaled to the local level. Data preparation can be intensive, but only a moderate level of GIS expertise is required. QUICKScan is a spatial modelling environment to combine expert knowledge with spatial and statistical data. It can enable policy-makers, experts and stakeholders to jointly explore, in a facilitated workshop, the impacts of different policy options on ecosystem services.
Citizen science (observations) Monitoring, mapping and horizon scanning frameworks	Toolkit for Ecosystem Services Site-based Assessment – TESSA v.2.0 (Peh et al., 2017) Ecosystem Services Toolkit (Value of Nature to Canadians Study Taskforce, 2017) Guidance Manual for TEEB Country Studies (TEEB 2013) Assessment guide to the social and economic benefits of protected areas (Kettunen and ten Brink 2013)

A.2 DECISION-SUPPORT FRAMEWORKS AND INSTRUMENTS

Instrument category and type	**Key resources and references**
Strategic Frameworks (EU and National)	
EU, national and regional biodiversity strategies, action plans, protected-areas management plans (e.g. Natura 2000), and programmes guiding EU funding	Framework for biodiversity proofing EU funding (e.g. national and regional programmes) (IEEP 2015) EU green infrastructure strategy and guidance on the strategic deployment of EU level green and blue infrastructure EU action plan for nature, people and the economy EU pollinators initiative EU thematic soil strategy EU forest strategy EU climate adaptation strategy National Restoration Prioritisation Frameworks National Prioritised Action Frameworks (PAFs) for biodiversity funding National and regional programmes guiding EU funding (e.g. Rural Development Programmes
Guiding principles	
CBD Ecosystem-based approach EU Precautionary principle	CBD Guidance: the Ecosystem Approach EU No Net Loss (NNL) of Biodiversity initiative and

No Net Loss and mitigation hierarchy Adaptive management	related assessments EU NNL operational principles EU studies on biodiversity offsetting IEEP guidance on NNL - Principles and practice for achieving NNL of biodiversity and ecosystem services (IEEP 2017) Ten Kate, Kerry. 2018. Improving the implementation of the mitigation hierarchy through policy. Benchmark for review of policy measures. Forest trends 2018. BBOP Roadmap and Benchmark for government performance on no net loss IUCN guidance on biodiversity offsets (IUCN) Biodiversity offsetting pilots - Information note for local authorities, providers and developers (Defra 2012) W. Wende et al. Biodiversity Offsets: European perspectives on No Net Loss of biodiversity and ecosystem services. Springer (2018) BBOP. 2018. Business Planning for Biodiversity Net Gain: A Roadmap. Forest trends 2018.
Ex-ante impact assessment procedures, risk assessment and analysis tools	
Strategic Environmental Assessment (SEA) and related guidance Environmental Impact Assessment (EIA) and related guidance Risk assessment protocols (e.g. for pesticides) Project selection and evaluation criteria Product Life Cycle Assessments (LCA) Multi-criteria / cost benefit analysis integrating ecosystem service values Scenario planning tools Corporate assessments of impacts on ecosystem services and related vulnerabilities and risks	EU SEA Guidance EU EIA Guidance EU Guidance documents on Integrating Climate Change and Biodiversity into EIA and SEA EU Better Regulation Guidelines, Toolbox e.g. multi-criteria analysis guidelines Environmental Risk Assessment (EEA) within which Ecological Risk Assessment Protocol – EcoRA (EEA) EU Guidance on LCA (EU Better Regulation Toolkit, Ch VIII) European Platform on Life Cycle Assessment (LCA) (JRC) Corporate Ecosystem Service Review (WBCSD 2012) Corporate Ecosystem Service Valuation (WBCSD 2011) Cement Sustainability Initiative (WBCSD) OPERAS and OPENESS

A.3. IMPLEMENTATION SUPPORT FRAMEWORKS AND INSTRUMENTS

Instrument category and type	Key resources and references
Dedicated legislative acts, regulations & standards	
EU, national and regional legislation: BHD, WFD, MSFD, MSP, to some extent IAS Criteria and standards for policy sectors, as set in guidance documents under legislation (e.g. Natura 2000-related guidance documents) Land-use and resource-use planning regulations (including the EU MSP Directive) Permitting procedures	EU Natura 2000 guidance documents EU WFD guidance documents EU MSP Platform
Spatially explicit instruments	
EU, national and regional networks Landscape plans Regional and urban spatial plans EU River Basin Management Plans Other zonation for marine space, land- and resource use Maritime Spatial Plans	Natura 2000 or other protection zones (e.g. for water supply) Natura 2000 viewer Regional green infrastructure networks
Public investment	
European Agricultural Guarantee Fund (EAGF) and European Agricultural Fund for Rural Development (EAFRD) European Maritime and Fisheries Fund (EMFF) EU Structural and Cohesion Funds (ERDF, ESF, CP) Connecting Europe Facility EU LIFE Programme Natural Capital Financing Facility (NCFF) National and regional funds	EAGF and EAFRD EMFF ERDF, ESF and CF CEF LIFE NCFF and guide for applicants Framework for biodiversity proofing EU funding (e.g. project selection and monitoring criteria) (IEEP 2015)
Market-based instruments and certification	
Payments for ecosystem services (PES) Offsetting schemes Green public procurement (GPP) Certification schemes Price signals (linked to certification/labelling but also fiscal measures such as taxes or subsidies that affect price)	Review of the uptake of PES, offsetting and certification schemes in the EU (Illes et al. 2017) Results-based Payments for Biodiversity Guidance Handbook (Defra 2014) Payments for Ecosystem Services - A Best Practice Guide (AECOM 2015) Buying Green - A Handbook on green public procurement (EC 2016) and collection of good practices (EC 2012) GPP for Circular Economy (EC 2017) EU FLEGT licences for sustainable timber

	Best Policy guidance for the integration of Biodiversity and Ecosystem services in standards (CBD 2012) Science for environment policy – Payments for ecosystem services
Voluntary instruments	
Promoted/endorsed global, regional or nation-wide practices (e.g. soil conservation practices) Voluntary codes of conduct Guidance documents	EU Guidance on Soil Sealing Making green economy happen: Integration of ecosystem services and natural capital into sectoral policies (Kettunen et al. 2017) IUCN guidelines and resources for nature-based solutions to climate-change adaptation , disaster-risk reduction , water and forests CBD Voluntary guidelines for ecosystem based approaches to climate adaptation and disaster risk reduction.

A.4 MONITORING AND EVALUATION SUPPORT INSTRUMENTS, REFERENCES AND RESOURCES

Instrument category and type	Key resources and references
Data, indicators, monitoring, mapping, accounting, and science-policy assessments	
See information instruments for the formulation stage above (table 1), but now for monitoring purposes, with insights supporting adaptive management	
Reporting, supported by indicators, monitoring and mapping	
Reporting and review frameworks for legislation (including evaluation and Fitness Checks) Frameworks and markers for tracking investment in biodiversity Obligatory reporting frameworks for business (e.g. non-financial reporting) Voluntary reporting frameworks (e.g. reporting framework for business sector)	European semester process for the coordination of economic policies EU framework for Regulatory Fitness and Performance (REFIT) Framework for tracking biodiversity expenditure under the EU budget
***Ex-post* impact assessment procedures**	
Ex-post assessments of policy instruments and related programmes (e.g. mid-term evaluations of funds and policies), with insights supporting adaptive management In relation to NNL/offsetting – monitoring frameworks embedded in permits	EU Better Regulation Guidelines and Toolbox, Ch VI on evaluations

A.5. INSTITUTIONAL AND STAKEHOLDER ENGAGEMENT INSTRUMENTS AND RESOURCES (CROSS-CUTTING TO ALL DECISION-MAKING STAGES)

Instrument category and type	Key resources and references
Institutional instruments and structures for integration	
Inter-ministerial or inter-sector coordination bodies Science-policy interfaces, e.g. expert advisory boards Community and / or stakeholder councils River basin councils, regional sea conventions etc. Sustainable business platforms, e.g. B@B, NCP	Community-led local development in the EU (2014-2020 funding period) Local Action Groups (LAG) database for EAFRD, EMFF, ESF and ERDF (ENRD) Community-led development in cities (URBACT 212) EU Business and biodiversity platform
Stakeholder engagement processes and mechanisms	
Stakeholder mapping and assessment Awareness raising campaigns and tools Stakeholder engagement processes (strategies and plans for information, consultation and active participation) and tools (online consultations, targeted interviews etc.)	EU guidance on stakeholder consultation (EU Better Regulation Toolkit, Ch VII) See section 3.2.4 and Box x for further guidance

B. INDICATIVE TABLES OF ECOSYSTEM SERVICES

MAES INDICATORS FOR ECOSYSTEM SERVICES PROVIDED BY FOREST, CROPLAND AND GRASSLAND, FRESHWATER AND MARINE ECOSYSTEMS

•	Available indicator to measure the condition of an ecosystem, or the quantity of an ecosystem service at a given CICES level for which harmonised, spatially-explicit data at European scale is available and which is easily understood by policy makers or non-technical audiences. Spatially-explicit data in this context refer to data that are at least available at the regional NUTS2 level or at a finer spatial resolution. CICES classifies ecosystem services at 4 hierarchical levels. Sometimes, it is more costeffective to consider an assessment of ecosystem services at a higher CICES level than at class level, especially if aggregated indicators are available. Indicators that aggregate information at higher hierarchical CICES level can therefore also have a green label.
•	Available indicator to measure the condition of an ecosystem, or the quantity of an ecosystem service at a given CICES level but for which either harmonised, spatially-explicit data at European scale is unavailable or which is used more than once in an ecosystem assessment, which possibly results in different interpretations by the user. This is typically the case for indicators that are used to measure ecosystem condition, which are reused to assess particular ecosystem services. This colour also includes indicators that capture partially the ecosystem service assessed.

•	Available indicator to measure the condition of an ecosystem, or the quantity of an ecosystem service at a given CICES level but for which no harmonised, spatially-explicit data at European scale is available and which only provides information at aggregated level and requires additional clarification to non-technical audiences. This category includes indicators with limited usability for an ecosystem assessment due to either high data uncertainty or a limited conceptual understanding of how ecosystems deliver certain services or how ecosystem condition can be measured. The ability to convey information to end users is limited and further refined and/or local level assessments should be used for verifying the information provided by this type of indicators.
•	Unknown availability of reliable data and/or unknown ability to convey information to the policy making and implementation processes.

B.1. FOREST AND WOODLAND ECOSYSTEMS

Indicators for provisioning services delivered by forest ecosystems (CICES classification)

Division	Group	Class	Indicators
Nutrition	Biomass	Cultivated crops	
		Reared animals and their outputs	• Meat production (Iberian pig species) • Meat consumption (Iberian pig species) • Number of individuals (Iberian pig) • Meat production (reindeer) • Meat consumption (reindeer) • Number of individuals (reindeer)
		Wild plants, algae and their outputs	• Distribution of heathlands and other habitats for bees • Distribution of plants important for honey production • Distribution of wild berries, fruits, mushrooms (NFI plot data) • Distribution of wild berries (modelling) • Honey production • Honey consumption • Wild berries, fruits and mushroom harvest
		Wild animals and their outputs	• Amount of meat (hunting) • Value of game • Hunting records (killed animals)
		Plants and algae from in-situ aquaculture	
		Animals from in-situ aquaculture	
	Water	Surface water for drinking	• Total supply of water per forest area (modelling) • Area of forest dedicated to preserve water resources • Surface water supply per forest area (at river basin level) • River discharge • Reservoir water (proxy) • Population and per capita water consumption
		Ground water for drinking	None
Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	• Forest biomass stock • Forest biomass increment • Forest for timber, pulp wood, etc. production • Commercial forest tree volume & harvesting rates • Trees (presence): cork oak for cork & pines for resins • Tree species (timber tress) • Wood consumption (industrial roundwood, fuelwood) • Consumption of cork and resins
		Materials from plants, algae and animals for agricultural use	• Distribution of foraging areas in forest; estimate of grassland/shrubland (NPP) • Marketed forage
		Genetic materials from all biota	• Distribution of plants species with biochemical /pharmaceutical uses • Raw materials for medicines
	Water	Surface water for non-drinking purposes	***Same as for drinking purposes***
		Ground water for non-drinking purposes	
Energy	Biomass-based energy sources	Plant-based resources	• Wood fuel stock (fraction of forest biomass stock) • Wood fuel production (fraction of forest biomass increment) • Distribution of tress for wood production • Fuel wood consumption
		Animal-based resources	
	Mechanical energy	Animal-based energy	

Indicators for regulating services delivered by forest ecosystems (CICES classification)

Division	Group	Class	Indicators
Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	
		Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	
	Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	● Area of forest ● Sulphur (S) and Nitrogen (N) retention and removal
		Dilution by atmosphere, freshwater and marine ecosystems	
		Mediation of smell/noise/visual impacts	
Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	● Erosion protection (modelling) ● Area of forest ● Area of forest designated to the prevention of soil erosion ● Area eroded by wind and water ● Forest cover in high slope areas (GIS analysis) ● Sediments removed from dams, lakes, rivers
		Buffering and attenuation of	● Forest area designated for attenuation of mass flows ●

		mass flows	Erosion risk mitigation • Flood risk mitigation
	Liquid flows	Hydrological cycle and water flow maintenance	• Forest area (designated to preserve water resources) • Number of floods • Water retention in forest • Snow cover • Infiltration • Capacity for maintaining baseline flow (modelling) • Water storage/delivery capacity of soil • Water supply and discharge (hydrological modelling) • Important areas for water infiltration and headwater surroundings covered by forest • Drought and water scarcity
		Flood protection	• Special protection areas for preventing mass flows linked to the River Basin Management Plans • Reforestation of forest territories against floods • Number of floods
	Gaseous / air flows	Storm protection	• Area of forest designated to protect infrastructure and managed nat. resources • Frequency of storms • Area of forest
		Ventilation and transpiration	None
Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	• Number of pollinator species • Number of bee hives • Abundance of pollinators (maps) • Areas managed for gene conservation • Pollination potential (maps) • Surface area of dependent crops • Honey production (modelling) • Honey consumption
		Maintaining nursery populations and habitats	• Tree species distribution • Conservation investments • Protected Areas for nursery populations • Forest area designated for habitat-landscape protection: Natura2000, etc.
	Pest and disease control	Pest control	• Host-species (trees) abundance • Surface of healthy Forests (quality parameter of forest health) • Number of pests and diseases • Surface affected by pests and diseases • Number of IAS • Surface occupied by IAS • Damage costs
		Disease control	None
	Soil formation and composition	Weathering processes	• Area of forest • Restoration costs • Forest soil condition: chemical soil properties
		Decomposition and fixing processes	• Soil organic matter • Amount of dead wood • Thickness of the organic layer
	Water conditions	Chemical condition of freshwaters	• Area of forest • Water quality • Forest area designated to preserve waters resources • Cost of water purification
		Chemical condition of salt waters	
	Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	• C storage in forest • C sequestration by forest (NPP; NEP) • Forest growth, growing stock • Number of CO2 emissions permits
		Micro and regional climate regulation	• Area of forest • Albedo maps • Foliar surface index • Ozone & particle pollution

Indicators for cultural services delivered by forest ecosystems (CICES classification)

Division	Group	Class	Indicators
Physical and intellectual interactions with biota, ecosystems, and land-/seascapes	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings. And physical use of land-/seascapes in different environmental settings	• Distribution of wildlife/emblematic species associated with forest • Important bird areas associated with forest • Area of forest accessible for recreation • Number of visitors • Number of hunters • Ecotourism operators • Area of forests accessible for hunting
	Intellectual and representative interactions	Scientific, educational, heritage, cultural, entertainment and aesthetic	• Citations, distribution of research projects, educational projects, number of historic records • Number/value of publications sold
Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes	Spiritual and/or emblematic	Symbolic and sacred and/or religious	• Distribution of sites of emblematic plants/forest • Number of sites with recognised cultural & spiritual value • Number of visitors
	Other cultural outputs	Existence and bequest	• Distribution of important areas for forest biodiversity and their conservation status • Condition of forest-associated priority species on habitat and birds directives • Distribution of sites with forest designated as having cultural values • Number of visitors

B.2. AGRO-ECOSYSTEMS: CROPLAND AND GRASSLAND ECOSYSTEMS

MAES Indicators for provisioning services delivered by agro-ecosystems

Division	Group	Class	Cropland	Grassland
Nutrition	Biomass	Cultivated crops	• Yields of food and feed crops (ton/ha; ton dry matter/ha; MJ/ha) • Food and feed crop area (ha)	• Yields (ton/ha; ton dry matter/ha; MJ/ha) • Grassland area (ha)
		Reared animals and their outputs	• Livestock data (LU/ha, Ton/yr/region)	
		Wild plants, algae and their outputs		
		Wild animals and their outputs	• Wild game bag data (merged with forest ecosystems) • Wild game population estimates	
		Plants and algae from in-situ aquaculture		
		Animals from in-situ aquaculture		
	Water	Surface water for drinking	• High Nature Value farmland	
		Ground water for drinking	• Areas important for groundwater abstraction in agro ecosystems	
Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	• Yields of fibre crops (ton/ha; ton dry matter/ha; MJ/ha) • Fibre crop area (ha) • Manure (ton/yr)	
		Materials from plants, algae and animals for agricultural use		
		Genetic materials from all biota	• Yields of crops used for medicinal and cosmetic purposes (ton/ha; ton dry matter/ha; MJ/ha) • Area of crops used for medicinal and cosmetic purposes (ha)	
	Water	Surface water for non-drinking purposes	***See freshwater ecosystems***	
		Ground water for non-drinking purposes	***See freshwater ecosystems***	
Energy	Biomass-based energy sources	Plant-based resources	• Yields of energy crops (ton/ha; ton dry matter/ha; MJ/ha) • Energy crop area (ha) • Biofuel, biodiesel, bioethanol (kToe)	• Yields of grassland for energy production (ton/ha; ton dry matter/ha; MJ/ha) • Grassland for energy area (ha)
		Animal-based resources	• Energy from manure treatment systems	
	Mechanical energy	Animal-based energy		

MAES indicators for regulating and maintenance services delivered by agro-ecosystems.

Division	Group	Class	Cropland	Grassland
Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals		
		Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals		
	Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	• Concentration of pollutants in soil in agricultural areas • Concentration of nutrient elements (C, N, P, K, Ca, Mg, S) in soil in agricultural areas	
		Dilution by atmosphere, freshwater and marine ecosystems		
		Mediation of smell/noise/visual impacts	• Hedgerow length	
Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	• Percentage of soil cover in cropland (conservation tillage (low tillage), zero tillage, winter crops, Cover crop or intermediate crop, plant residues) • Density of hedgerows • Soil erosion risk	• Percentage of grassland cover • Soil erosion risk
		Buffering and attenuation of mass flows	• Density of hedgerows	
	Liquid flows	Hydrological cycle and water flow maintenance	• Retention capacity of water in agricultural soils	
		Flood protection	• Share of agroforestry within floodplains	
	Gaseous / air flows	Storm protection	• Density of hedgerows	
		Ventilation and transpiration	• Amount of biomass	
Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	• Pollination potential • Pollinators distribution • Pollinators species richness • Number of beehives • Areal coverage of vegetation features supporting pollination (hedgerows, flower strips, High Nature Value Farmland etc.)	
		Maintaining nursery populations and habitats	• Share of High Nature Value farmland • Traditional orchards	
	Pest and disease control	Pest control	• Density of hedgerows	
		Disease control		
	Soil formation and composition	Weathering processes	• Share of organic farming • Soil organic matter content • Ph of topsoil • Cation exchange capacity	
		Decomposition and fixing processes	• Area of N fixing crops • Gross nitrogen balance	
	Water conditions	Chemical condition of freshwaters	***See water pilot***	
		Chemical condition of salt waters	***See water pilot***	
	Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	• Carbon sequestered by permanent crops	• Carbon sequestered by grasslands
		Micro and regional climate regulation	• Humidity index	

MAES indicators for cultural services delivered by agro-ecosystems

Division	Group	Class	Cropland	Grassland
Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	• Number of visitors in agricultural areas • Number of Number of rural enterprises offering tourism-related services • Farm tourism • Walking and biking trails • Number of hunting licences, number of birdwatchers • Expenditures related to hunting	
		Physical use of land-/seascapes in different environmental settings		
	Intellectual and representative interactions	Scientific	• Amount of scientific studies on agro-ecosystems	
		Educational	• Number of didactic farms	
		Heritage, cultural	• Number of agricultural-livestock fairs • Number of monuments in agricultural areas • Number of certified products that require traditional landscape management	
		Entertainment	• Contests and competitions related to agriculture	
		Aesthetic	• Number of visitors in agricultural areas • Number of nature/agricultural landscape photos uploaded on web portals	
Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	• Remarkable trees • Symbolic species	
		Sacred and/or religious	• Religious monuments, pilgrim paths in agro-ecosystems	
	Other cultural outputs	Existence	• Cropland or grassland in protected agricultural areas (e.g. Natura2000, Biosphere reserves, IUCN category V areas, World Heritage Unesco sites related to agricultural landscape, landscape conservation areas)	
		Bequest	• Willingness to pay for landscape measures in cropland or grassland areas	

B.3. FRESHWATER ECOSYSTEMS

MAES Indicators for ecosystem services delivered by freshwater ecosystems (Indicators in red font are subject to discussion)

Division	Group	Class		Lakes	Rivers	Ground water	Wetlands
Nutrition	Biomass	Cultivated crops					
		Reared animals and their outputs					
		Wild plants, algae and their outputs		• Wild plants used in gastronomy, cosmetic, pharmaceutical uses (data on industries collecting the plants)			***see lakes and rivers***
		Wild animals and their outputs		• Fish production (catch in tonnes by commercial and recreational fisheries) • Number of fisherman and hunters of waterfowls (anglers, professional and amateur fishermen) • Status of fish population (Species composition, Age Structure, Biomass kg/ha)			***see lakes and rivers***
		Plants and algae from in-situ aquaculture					
		Animals from in-situ aquaculture		• Freshwater aquaculture production (e.g. sturgeon and caviar production)			
	Water	Surface water for drinking	• Water exploitation index (WEI)	• Water consumption for drinking • Surface water availability • Water abstracted			• Nitrate-vulnerable zones
		Ground water for drinking				• Ground water bodies • Ground water abstraction	
Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing					• Wood produced (tons or volume) by riparian forest • Surface of exploited wet forests (e.g. poplars) and reeds
		Materials from plants, algae and animals for agricultural use					
		Genetic materials from all biota					
	Water	Surface water for non-drinking purposes	• Water exploitation index (WEI)	• Water use per sector • Surface water availability • Water abstracted • Volume of water bodies			• Surface of flood-prone areas
		Ground water for non-drinking purposes				• Ground water bodies • Ground water abstraction	

.

Division	Group	Class	Lakes	Rivers	Ground water	Wetlands
Energy	Biomass-based energy sources	Plant-based resources				• Firewood produced by riparian forests
		Animal-based resources				
	Mechanical energy	Animal-based energy				
Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	• Indicators on water quality (microbiological data for bathing waters, BOD5 nitrate conc, phosphate conc, oxygen conditions, saprobiological status) • Nutrient loads • Ecological status • Trophic status • Area occupied by riparian forests • Number and efficiency of treatment plants • Waste treated		• Indicators on groundwater quality (NO3, pesticide, trace metals, emerging pollutants, etc. evolution in GW)	• Carbon storage per unit of area • Potential mineralization or decomposition • Ecological status • Nutrient concentration • Nutrient retention
		Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals				
	Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems				
		Dilution by atmosphere, freshwater and marine ecosystems				
		Mediation of smell/noise/visual impacts				
Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates			• GW level evolution	
		Buffering and attenuation of mass flows	• Sediment retention			• Sediment retention
	Liquid flows	Hydrological cycle and water flow maintenance	Volume of water (or snow)	Hydrological flow data		Surface of wetlands
		Flood protection	• Holding capacity flood risk maps • Conservation of river and lakes banks			• Water holding capacity of soils • Floodplains areas (and record of annual floods) • Area of wetlands located in flood risk zones • Conservation status of riparian wetlands
	Gaseous / air flows	Storm protection				• Conservation status of wetlands Area of wetlands, vegetation cover?
		Ventilation and transpiration				
Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal			• GW level	Beekeeping value of wetlands
		Maintaining nursery populations and habitats	• Biodiversity value (Species diversity or abundance, endemics or red list species and spawning location) • Ecological status Morphological status			Biodiversity value?
	Pest and disease control	Pest control	• Alien species (Introduced riparian and aquatic plants • Number of introduced aquatic invertebrates • Number of introduced vertebrates in rivers and riparian areas			***see lakes and rivers***
		Disease control				
	Soil formation and composition	Weathering processes	• Fluvisols surface			• Hydromorphic soils (Presence/absence) Surface of floodplains
		Decomposition and fixing processes				• Potential mineralization, decomposition, etc.
	Water conditions	Chemical condition of freshwaters	• Chemical status • Ecological status		• Indicators of GW quality	• Chemical status • Ecological status • Potential of water purification of wetlands
		Chemical condition of salt waters				
	Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	• C sequestration (Annual increase in • Carbon sequestration in living biomass of riparian forest • Carbon sequestered by plantations of *Populus* • Organic carbon stored in fluvisols)		• C sequestration (Evolution of annual volumes of CO_2 injected, • Number of sites for CO_2 deep injections)	see rivers and lakes
		Micro and regional climate regulation			• GW level	
Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	• Number of visitors (to National Parks including lakes or rivers) • National Parks and Natura 2000 sites • Known bird watching sites Waterfowl			• Number of visitors (waterfowl hunters and fishermen, • Visitors to National Parks or protected areas including wetlands) • Known bird watching sites • Waterfowl • Tourism revenue
		Physical use of land-/seascapes in different environmental settings	• Number of visitors • bathing areas and Number beaches • Fishing reserves, • Fish abundance, • Fish monetary value from angling, • Number fishing licenses, • Quality of fresh waters for fishing		• Number of visitors (to thermal, mineral and mud springs and beaches, to Natural Reserve areas) speleology sites	• Number of visitors (waterfowl hunters and fishermen) • Number of fishing licenses • Tourism revenue
	Intellectual and representative interactions	Scientific	• Monitoring sites (by scientists) • Number of scientific projects, articles, studies • Classified sites (world heritage, label European tourism)			
		Educational	• Number of visitors			

Division	Group	Class	Lakes	Rivers	Ground water	Wetlands
			• National Parks and Natura 2000 sites			
		Heritage, cultural	• Number of visitors • Natural heritage and cultural sites • Number of annual cultural activities organised			
		Entertainment	Number of visitors (surface or number of wetlands located next to a bike path)			
		Aesthetic	• Number of visitors • Contrasting landscapes (lakes close to mountains) • Proximity to urban areas of scenic rivers or lakes			
Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	• National species or habitat types		• Number of visitors (to places where springs and streams with GW origin made them historic and religious sites)	• National species or habitat types
		Sacred and/or religious	• sacred/religious sites (catastrophic events, religious places)			• sacred/religious sites (catastrophic events, religious places)
	Other cultural outputs	Existence	• Number of visitors (to National Parks including lakes) • Number of fishing licenses		• Number of visitors (to hot mineral spring waters)	***See rivers and lakes***
		Bequest	• Number of association registered on animals, plants, environment, naturism			***See rivers and lakes*** Social perception of wetlands

B.4. MARINE ECOSYSTEMS

Indicators for ecosystem services delivered by marine ecosystems

Division	Group	Class	Marine inlets and transitional waters	Coastal waters	Shelf waters	Open Ocean
Nutrition	Biomass	Cultivated crops				
		Reared animals and their outputs				
		Wild plants, algae and their outputs	• Harvest (ton/a)			
		Wild animals and their outputs	• Landings (ton)		• Landings (ton) • CPUE (ton)	
		Plants and algae from in-situ aquaculture	• Harvest (ton/a)			
		Animals from in-situ aquaculture	• Harvest (ton/a)			
	Water	Surface water for drinking				
		Ground water for drinking				
Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	• Harvest (ton/a)	• Landings (ton) • Harvest (ton/a)		
		Materials from plants, algae and animals for agricultural use		• Landings (ton) • Harvest (ton/a)		
		Genetic materials from all biota	• Patents (no.) • Published articles (no.)			
	Water	Surface water for non-drinking purposes				
		Ground water for non-drinking purposes				
Energy	Biomass-based energy sources	Plant-based resources				
		Animal-based resources				
	Mechanical energy	Animal-based energy				
Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	• Nutrient load to coast (ton/a) • HM and POP deposition (ton/a) • Oxyrisk			• HM and POP deposition (ton/a) • Oxyrisk
		Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals				
	Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems				
		Dilution by atmosphere, freshwater and marine ecosystems				
		Mediation of smell/noise/visual impacts				
Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	• Composite indices based on extent of selected emerged, submerged and intertidal habitats, coastline slope and coastal geomorphology, wave regime, tidal range, relative sea level, storm surge			
		Buffering and attenuation of mass flows				
	Liquid flows	Hydrological cycle and water flow maintenance				
		Flood protection	***See buffering and attenuation of mass flows***			
	Gaseous / air flows	Storm protection				
		Ventilation and transpiration				

Division	Group	Class	Marine inlets and transitional waters	Coastal waters	Shelf waters	Open Ocean
Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal				
		Maintaining nursery populations and habitats	• Submerged and intertidal habitats diversity (no.) • Oxygen concentration (%) • Turbidity (%) • Species distribution (km^2/ha) • Abundance and richness - at age (ton/a) • Extent of marine protected areas (km^2/ha) •Nursery areas (km^2/ha)		• Oxygen concentration (%) • Turbidity (%) • Species distribution (km^2/ha) • Abundance and richness - at age (ton/a) • Extent of marine protected areas (km^2/ha) •Nursery areas (km^2/ha)	
	Pest and disease control	Pest control	• Presence (no.) and • Distribution (km^2) of alien species			
		Disease control				
	Soil formation and composition	Weathering processes				
		Decomposition and fixing processes	• Nitrogen removal (%) • Water residence time (months) • Depth/water residence time (m/year)			
	Water conditions	Chemical condition of freshwaters				
		Chemical condition of salt waters	• Nutrient load to coast (ton/yr) • HM and POP loading (ton/yr) • Oxyrisk			
	Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	• C stock (tonC) • C sequestration (tonC/a) • pH • blue C (tonC) • PP(ton C/year)			
		Micro and regional climate regulation				
Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	• Extent of marine protected areas (km^2/ha) • Presence of iconic/endangered species (no.) • In-water activities occurrence (no.) • Recreation trips (no./year)			• Extent of marine protected areas (km^2/ha) • Presence of iconic/endangered species (no.)
		Physical use of land-/seascapes in different environmental settings				
	Intellectual and representative interactions	Scientific	• Scientific studies (no.) • Documentaries, educational publications (no.) • Visits to scientific and artistic visits exhibits (no.)			
		Educational				
		Heritage, cultural				
		Entertainment	• Documentaries, educational publications (no.) • Visits to scientific and artistic visits exhibits (no.)			
		Aesthetic				
Spiritual, symbolic and other interactions with	Spiritual and/or emblematic	Symbolic				
		Sacred and/or religious				

Division	Group	Class	Marine inlets and transitional waters	Coastal waters	Shelf waters	Open Ocean
biota, ecosystems, and land-/seascapes [environmental settings]	Other cultural outputs	Existence	• Extent of marine protected areas (km^2/ha) • Presence of iconic/endangered species (no.)			
		Bequest				

B.5. URBAN ECOSYSTEMS

MAES Indicators for provisioning services of urban ecosystems

CICES Division - Group					
Nutrition - Biomass					
Class	**Class type (urban ecosystem service)**	**Indicator (unit)**	**Relevant spatial extent**		
			R	**M**	**U**
Cultivated crops	Vegetables produced by urban allotments and in and the commuting zone	• Production of food (ton ha^{-1} year^{-1})	•	•	
		• Surface of community gardens /small plots for self-consumption (ha)		•	•
Nutrition - Water					
Surface/ground water for drinking		• Drinking water provision (m^{3} ha^{-1}year^{-1})	•	•	
		• Drinking water consumption (m^{3} year^{-1})	•	•	•
Materials - Water					
Surface/ground water for non-drinking		• Water provision (m^{3} ha^{-1}year^{-1})	•	•	
		• Water consumption per sector (m^{3} year^{-1})	•	•	•

MAES indicators for regulating services provides by urban ecosystems (CICES)

CICES Division - Group					
Mediation of waste, toxics and other nuisances - Mediation by ecosystems					
Class	**Class type (urban ecosystem service)**	**Indicator (unit)**	**Relevant spatial extent**		
			R	**M**	**U**
Filtration/ sequestration/storage/ accumulation by ecosystems	Regulation of air quality by urban trees and forests	• Pollutants removed by vegetation (in leaves, stems and roots) (kg ha^{-1} year-1)		•	•
		• Dry deposition velocity (mm s^{-1})		•	•
		• Population exposed to high concentrations of pollutants (% on surface area)		•	•
Mediation of smell/noise/visual	Noise mitigated by urban vegetation	• Leaf Area Index + distance to roads (m)		•	•
		• Noise reduction rates applied to UGI within a defined road buffer dB(A) m^{-2} vegetation unit (Derkzen et al. 2015)		•	•
Mediation flows-Liquid flows					
Hydrological cycle and water flow maintenance	Water flow regulation and run off mitigation	• Soil water storage capacity (mm)	•	•	•
		• Soil water infiltration capacity (cm)	•	•	•
		• Water retention capacity by vegetation and soil (ton km^{-2})	•	•	•
		• Intercepted rainfall (m^3 $year^{-1}$)	•	•	•
		• Surface runoff (mm)	•	•	•
Flood protection	Flood protection by appropriate land coverage	• Share of green areas in zones in danger of floods (%)		•	•
		• Population exposed to flood risk (% per unit area)		•	•
		• Areas exposed to flooding (ha)		•	•
Maintenance of physical chemical biological conditions - Lifecycle maintenance, habitat and gene pool protection					
Pollination and seed dispersal	Insect pollination	• Capacity of ecosystems to sustain insect pollinators activity (dimensionless) (Zulian et al. 2013)	•	•	
		• Relative abundance (number over area or over a length)	•	•	
Maintenance of physical, chemical, biological conditions - Atmospheric composition and climate regulation					
Global climate regulation by reduction of greenhouse gas concentrations	Climate regulation by reduction of CO_2	• Carbon storage in soil (ton C ha^{-1})	•	•	
		• Carbon sequestration (ton ha^{-1} $year^{-1}$)	•	•	

Micro and regional climate regulation	Urban temperature regulation	● Leaf Area Index		●	●
		● Temperature decrease by tree cover (°C m^{-2})		●	●
		● Cooling capacity of UGI (Zardo et al.)		●	●
		● Cooling capacity of UGI (Derkzen et al. 2015)		●	●
		● Cooling capacity of UGI (Grêt-Regamey et al. 2014)		●	●
		● Population exposed to high temperatures (% per unit area)		●	●

MAES indicators for cultural services provided by urban ecosystems (CICES).

CICES Division - Group					
Physical and intellectual interactions with ecosystems and land-/seascapes [environmental settings] – Physical and experiential interactions					
Class	**Class type (urban ecosystem service)**	**Indicator (unit)**	**Relevant spatial extent**		
			R	**M**	**U**
Physical use of land-/seascapes in different environmental settings	Nature-based recreation	● Accessibility[15] to public parks, gardens and play-grounds (more than 50 ha) - (inhabitants within 10 km from a park)	●	●	●
		● Accessibility to public parks gardens and play-grounds (between 10 ha and 50 ha) - (inhabitants within 1 km from a park)	●	●	●
		● Accessibility to public parks gardens and play-grounds (between 2.5 ha and 10 ha) - (inhabitants within 500 m from a park)		●	●
		● Accessibility to public parks gardens and play-ground (between 0.75 ha and 2.5 ha or smaller but important green spaces) - (inhabitants within 250 m from a park).			●
		● Weighted recreation opportunities provided by Urban Green Infrastructure (Derkzen et al. 2015)			●
		● Nature based recreation opportunities (includes Natura 2000; includes bathing water quality) (dimensionless) (Zulian et al. 2013)	●	●	
		● Proximity of green infrastructure to green travel routes (km)	●	●	●
		● Green related social service provided to population (dimensionless) (Secco and Zulian 2008)			●
		● Regression models on georeferenced data (i.e. pictures or geo tagged locations) (Tenerelli et al. 2016)	●		
Physical and intellectual interactions with ecosystems and land-/seascapes [environmental settings] – Intellectual and representative interactions					
Educational Scientific	Nature-based education	● Accessibility of parks from schools (number of public parks and gardens within a defined distance from a school)		●	●
Heritage, cultural		● Cultural and natural heritage sites[16] (e.g., UNESCO world heritage sites) (number per unit area, % per unit area)	●	●	●

C. CASE STUDIES

C.1. GUIDELINES FOR THE DESIGN OF MULTIPLE CROPPING SYSTEMS TO PROVIDE MULTIPLE ECOSYSTEM SERVICES

This voluntary guidance by the French Institut National de la Recherche Agronomique (INRA) (2015) can help farm-sector stakeholders to support soil quality and the delivery of multiple ecosystem services via improved agricultural practices (multiple cropping). The case is especially relevant in illustrating approaches under Chapter 3 (instruments — voluntary guidance) and Chapter 4 (agriculture sector guidance).

In 2015, the French Institut National de la Recherche Agronomique published *Guidelines for the design of multiple cropping systems as drivers for providing multiple ecosystem services.* These guidelines introduce a cascade model of ecosystem services in agricultural systems: agricultural practices influence the physical and biological structures and processes in the cropping system, which in turn affect ecosystem functions and related ecosystem services.

The guidelines draw on the scientific literature on multiple cropping systems that use biotic interactions to reduce chemical inputs and provide a wider range of ecosystem services. The review concluded that multiple cropping systems can reduce:

- nutrient inputs and water, if the species or cultivars selected have complementary traits and strategies for acquiring such resources;
- pesticide use, if the cropping system creates habitats that are unsuitable for typical pest species or are suitable for other species that control pests, such as insect herbivores;
- erosion and nutrient loss, e.g. by using legumes to fix atmospheric nitrogen.

These benefits help to sustain air and water quality, and to support biodiversity and soil fertility in agricultural systems.

The first step of the guidelines is the identification of the target ecosystem services, and the ecosystem functions on which these services rely. The guidelines state that decision-makers should consult stakeholders such as farmers, residents, industry and environmental organisations to identify the services they require from the agricultural system in the short and medium term. These needs should then be formulated as objectives. Constraints on the provision of these services should be identified (for example constraints such as labour availability, prices of inputs and soil quality). Assessment indicators can then be identified to quantify service provision using either field experiments or models.

The second step focuses on selecting species and/or genotypes that have the necessary functional characteristics to provide the identified target ecosystem services. The assessment of suitable species can be based on expert knowledge, scientific literature or existing databases of crop characteristics. The guidance outlines two possible approaches for assessing interactions between selected species.

The third step addresses the design of a multiple cropping system, including how to arrange the crops in time and space and how to manage the cropping system to ensure the delivery of ecosystem services. The optimal arrangement depends on the species, ecosystem services and constraints identified in the first step. The management of the system depends on local environmental and socioeconomic conditions.

These conceptual guidelines require testing of both the decision-making process and the ecosystem services provided by multiple cropping systems. The authors highlight lessons that can be learnt from the current state of knowledge on multiple cropping systems, but they also stress the need for further research on the links between plant physiology and ecology, and between ecosystem functions and services. They also suggest that promoting multiple cropping systems may require the adjustment of market mechanisms and the development of local markets.

More information:

Gaba, S., Lescourret, F., Boudsocq, S. et al., 2015. Multiple cropping systems as drivers for providing multiple ecosystem services: from concepts to design. Agronomy for Sustainable Development, 25 (2): 607-623.

Haines-Young, R. and Potschin, M., 2010. The links between biodiversity, ecosystem services and human wellbeing. In Ecosystem Ecology: A new Synthesis. Cambridge University Press, Cambridge.

C.2. ECOSYSTEM SERVICES IN THE RIVER BASIN MANAGEMENT PLAN FOR SCOTLAND, THE UK

The river basin management plan (RBMP) for the Scotland river basin district integrates a range of ecosystem services, including recreation; aquaculture and fish farming; angling; renewable energy generation; provision of freshwater; waste recycling; and the manufacture of food and drink. The case study is especially relevant in illustrating: (i) the use of ecosystem-service valuation to support decision-making and stakeholder consultation (Chapter 3); (ii) the use of strategic environmental assessments (SEAs) and RBMPs to support decision-making and stakeholder consultation (Chapter 4); (iii) the use of spatial planning (Chapter 5); and (iv) water quality policy (Chapter 4).

The RBMP of the Scotland river basin district is the primary tool for achieving good ecological status under the EU Water Framework Directive. The various methods used to integrate ecosystem services into the first and second rounds of RBMPs are outlined below.

Ecosystem service valuation: The preparatory work for the first RBMP (to cover the period 2009–2015) included an economic analysis of water use in the river basin district and an assessment of a limited set of ecosystem services (this limited set of ecosystem services included clean drinking water, irrigation, industrial water use, aquaculture and salmon angling). Valuation methods used included netback analysis, avoided cost, willingness to pay, stated preference and travel cost. Some of these valuation methods also made use of the benefits transfer method. The analysis of the value of water for different uses, and of the impacts of economic activities on water, was used to inform the programme of measures in the first draft RBMP.

Strategic environmental assessment (SEA): The draft of the first RBMP was subject to an SEA, which addressed the potential impacts of the measures on a range of parameters related to ecosystem services (although the term ‘ecosystem services’ itself was not used). The SEA determined that the measures had many positive impacts on biodiversity; water quality; recreation; amenity value; mitigation of — and adaptation to — floods and drought; and climate change adaptation. The SEA also proposed methods to mitigate adverse impacts on these parameters. The SEA considered a baseline scenario without RBMP, a scenario that implemented the proposals in the draft RBMP, and a continued improvement scenario (implementation of RBMP measures plus additional measures). The assessment incorporated stakeholders’ input through a consultation on the RBMP and on the SEA itself. As a result, the first RBMP integrates ecosystem services as being among the ‘multiple benefits’ provided by aquatic ecosystems in good condition, which support the well-being of people and the economy.

The second RBMP refers to the ‘wider range of benefits’ that can be delivered if the condition of waterbodies is improved. An SEA was not deemed necessary for this iteration, but a statutory consultation was conducted on the current condition of Scottish waterbodies and the challenges these waterbodies faced in the future. In addition, the consultation document referred to the ‘range of benefits that the water environment provides to us’. The Scottish Environmental Protection Agency also created a data application with an interactive tool containing maps of ecosystem services by individual waterbodies.

Stakeholder engagement: The programmes of measures in the RBMP include a range of legislative instruments, education initiatives, regulatory checks, codes of practice, and economic instruments to reduce pressures on the water environment and deliver multiple benefits. The measures are further elaborated at the sub-basin level in area management plans developed and implemented by multi-stakeholder area advisory groups. In some cases, local-catchment management groups develop and implement the RBMP at local level. For example, projects in the Forth sub-basin have embraced the concept of multiple benefits from improving the ecological condition of waterbodies.

Monitoring: the Scottish Environmental Protection Agency ensures implementation of the RBMP and monitors the progress of this implementation. The condition of waterbodies is reviewed annually, reported on every 6 years, and used to inform future planning cycles.

The above analysis was part of the EU-funded Openness project. It also analysed four other RBMPs and identified benefits from ecosystem-service integration including:

- prioritising multi-functional and sustainable solutions;
- integrating different policy objectives;
- identifying measures that are beneficial for different stakeholder groups;
- assessing trade-offs; and
- informing cost-recovery for water services.

Stakeholders that were interviewed endorsed these findings but they also highlighted a number of challenges. One challenge is that the concept of ecosystem services is not always clear — it can be misinterpreted and misapplied. Some stakeholders also expressed concern that the concept of ecosystem services promotes the commodification of nature and that quantifying ecosystem services remains challenging. More knowledge is needed to develop guidelines for the valuation and integration of ecosystem services in river basin management planning.

More information:

Grizzetti, B., Liquete, C., Antunes, P. et al., 2016. Ecosystem services for water policy: Insights across Europe. Environmental Science and Policy, 66: 179-190.

SEPA, 2009. Scottish River Basin Management Plan and supporting documents. https://www.sepa.org.uk/environment/water/river-basin-management-planning/publications/

C.3. NATURAL CAPITAL ASSESSMENT TO SUPPORT MARINE SPATIAL PLANNING IN THE MEDITERRANEAN SEA, ITALY

Natural capital assessment is a useful tool to support spatial planning, and the 'zonation' (creating zones in which certain activities are allowed or prohibited) of marine protected areas (MPAs) and the wider sea scape. This helps to improve both human well-being and the conservation of ecosystems. In the Egadi Islands MPA in Italy, natural capital accounting has helped to identify further needs for conservation zonation to improve the marine reserve's effectiveness. This case study is relevant to natural capital accounting (Chapter 3) and marine spatial planning (Chapter 4).

In 2014, the Italian Ministry of the Environment and Protection of Land and Sea financed a four-year research programme based on the implementation of an environmental accounting system in Italian MPAs (the EAMPA project). The main goal of the programme was the assessment of the ecological and economic value of the MPAs, focusing on each protected area's (i) stocks of natural-capital and (ii) flows of ecosystem services. The programme sought to take into account the impact of human activities. When finalised, the conclusions drawn from this research will be used to support both managers and decision makers in the preservation of areas targeted by conservation efforts.

Framework for natural capital accounting: The valuation of natural capital in the Egadi Islands MPA (EI-MPA) was carried out by using the 'emergy accounting' method (Picone et al. 2017). The emergy accounting method incorporates biophysical and trophodynamic environmental accounting, generating values that correspond to the environmental support provided to systems.

The accounting of EI-MPA was carried out through the following steps:

1. identification of the boundary (spatial and temporal) of the EI-MPA and its main habitats;

2. modelling the MPA through a system diagram in standardised energy-systems language, as shown in Figure 1;

3. sampling the main taxonomic groups identified in the habitats of the MPA, to create a biomass inventory;

4. conducting a trophodynamic analysis, where an estimate is generated of the primary productivity used to support the benthic trophic chain within the MPA;

5. calculating the main matter and energy flows that supported the generation of natural capital in the different habitats of the MPA, and converting these flows into solar emergy units;

6. calculating the annual matter and energy flows maintaining natural capital in the habitats of the MPA, and converting these flows into solar emergy units.

This natural capital and ecosystem-service flow can then be transferred into monetary values, which can be used to aid decision-making.

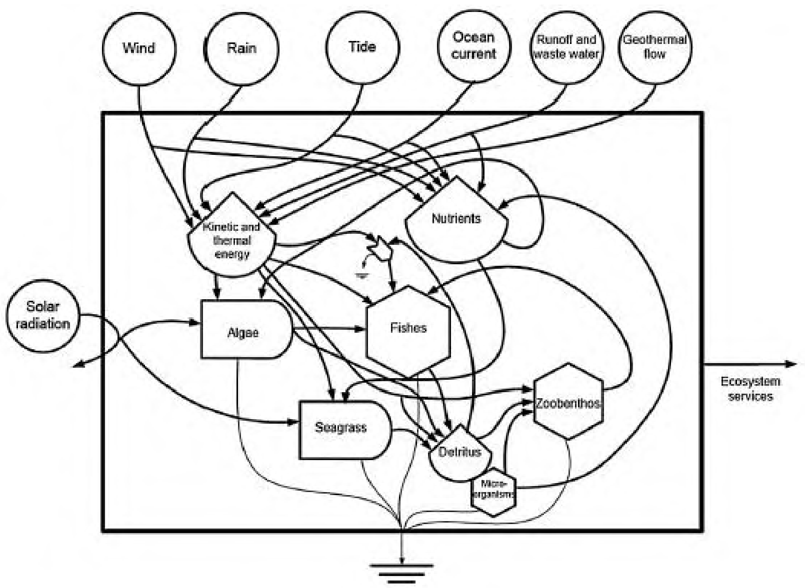

Figure 1: An energy systems diagram. The different shapes and notations are typical of energy-system language. They illustrate the inputs and outputs of the system and the relationships between these inputs and outputs (summarised in Franzese et al. (2017)).

Role of modelling and scenarios: Marxan software (a suite of free modelling tools) was used to integrate the results into decision-making and conservation planning. The software integrated the environmental accounting data (as calculated through the above processes) with spatial data on human use of the MPA (such as fishing, diving, bathing etc.). Two different scenarios were modelled, one with the impact of human uses of the MPA, the other without. These two scenarios identified areas where natural capital stocks are greatest, and can help develop management strategies to ensure the preservation of these areas (Picone et al., 2017).

The results showed that *Posidonia oceanica* seagrass beds had the highest autotrophic emergy density. This habitat also had the highest values of total emergy converging to generate both the autotrophic and heterotrophic stocks. The EI-MPA has the largest meadow of *P. oceanica* among all European reserves — its non-market monetary value was found to be EUR 900 million, representing 76 % of the total value of natural capital in the whole MPA. The sciaphilic hard-bottom habitat (coralligenous) was found to have the highest heterotrophic emergy density, but its extent was found to be limited in the EI-MPA.

The comparison analysis using Marxan software illustrated that, when taking into consideration the effects of human use, the sea around some areas of the EI-MPA was adequately protected in terms of protecting key areas for natural capital, while other areas were not. Therefore, there is scope for a new zonation area around Favignana Island (the largest in the archipelago) to improve the effectiveness of the marine reserve.

More information:

Picone, F., Buonocore, E., D'Agostaro, R., Donati, S., Chemello, R. & Franzese, P. P. (2017) Integration natural capital assessment and marine spatial planning: A case study in the Mediterranean Sea. Ecological Modelling. 361, 1-13.

Franzese, P. P., Buonocore, E., Paoli, C., Massa, F., Stefano, D., Fanciulli, G., Miccio, A., Mollica, E., Navone, A., Russo, G., Povero, P. & Vassallo, P. (2015). Environmental Accounting in Marine Protected Areas: the EAMPA Project. Journal of Environmental Accounting and Management. 3, 324-332.

Odum, H.T. (1996) Environmental Accounting: Emergy and Environmental Decision Making. John Wiley ISBN: 978-0-471-11442-0

C.4. NATURE-BASED APPROACHES TO CLIMATE-CHANGE ADAPTATION IN COPENHAGEN, DENMARK

Nature-based solutions that build on an understanding of ecosystem services form an integral part of climate-change-adaptation plans for urban areas. Copenhagen has developed an ecosystem-services-based urban planning approach to climate-change adaptation, supporting decision-making at project level. This case study is relevant to: scenarios and ecosystem services valuation, and tools to support decision-making (Chapter 3); and (urban) spatial planning (Chapter 4).

Following the COP15 climate summit in Copenhagen in December 2009, the municipality of Copenhagen adopted a climate-change-adaptation plan in 2011. The plan integrates the use of nature-based solutions and acknowledges that nature-based solutions may — in a cost-efficient way — help address a range of challenges that the city is facing. The plan specifically mentions the potential of nature-based solutions to absorb and retard storm water (thus preventing flooding); moderate and balance temperature in the city; create shade and air circulation (which assists in reducing the city's future energy consumption); help to cool buildings; remediate and reduce air and noise pollution; prevent stress; create opportunities for recreation; and serve as a home for animals and plants.

A 2008 climate-change risk assessment3 had identified cloudbursts as the largest immediate threat to Copenhagen and its residents. In 2011, the city was hit by heavy rains causing flooding in central Copenhagen.4 This prompted the municipality to develop a cloudburst management plan (2012) — under the framework of the adaptation plan — outlining methods, priorities and recommended measures for how to adapt the city to this challenge. The management plan is based on detailed flood mapping and risk analyses, and identifies about 300 site-specific adaptation projects to be implemented throughout the city over the coming 20 years.5

Role of ecosystem-service assessment and scenarios: No ecosystem-service assessment appears to have been carried out to support the preparation of the 2011 adaptation plan. However, the plan includes an assessment of five scenarios that (i) integrate, at some level, an understanding of ecosystem services, and (ii) estimate the costs of implementing different adaptation approaches. The results of the assessment showed that expanding the city sewer system would result in a net loss to society. However, the assessment also deemed that regulating the inflow into sewers using sustainable urban drainage systems (such as green roofs, rain gardens and swales), in combination with backwater valves and surface adaptations, was the best intervention in societal terms.

Role of ecosystem-service valuation: In 2015, the climate-change-adaptation plan was complemented by a strategy document, *Urban Nature in Copenhagen, Strategy 2015-2025*. The purpose of this strategy document was to further acknowledge and promote the integration of ecosystem services in the future-proofing of the city. One of the goals of the urban nature strategy is to ensure that the ongoing work on climate-change adaptation in Copenhagen helps to create more urban nature, improve biodiversity, and create more recreational experiences. The strategy integrates an understanding of ecosystem services, and builds on research into the value of nature. This research includes studies of (i) the frequency and length of visits to nature, and (ii) residents' opinions on nature areas (these opinions are gathered in various ways such as questionnaires, pedestrian counts and surveys on transportation habits).6

Development of a tool to support decision-making and evaluation: To find additional ways of implementing nature-based adaptation, the municipality worked with an expert group to develop an ecosystem services-based urban-planning approach. This approach combines climate-change adaptation and urban nature in a modelling tool. The modelling tool — called the Copenhagen model — produces a 'greening factor' that compares the size and quality of urban nature in an existing neighbourhood with the size and quality of urban nature in a proposed project. The modelling tool is based on a range of ecosystem services delivered by urban nature. The expert group identified five cultural ecosystem services as the 'glory values' delivered by urban nature in Copenhagen (community, sense, learning, co-existence and affiliation), and seven regulating and maintenance ecosystem services as 'use values' (noise reduction, air quality, water quality, CO_2 reduction, regulation of micro climate, rain water handling, and food cultivation).

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3 Based on technical and cost-benefit analyses by COWI https://www.cowi.com/solutions/environment/climate-adaptation-plan-for-copenhagen and the work by the Danish Nature Agency's Task Force on Climate Change Adaptation.
4 http://en.klimatilpasning.dk/media/600858/130206_mapping_climate_change_final.pdf .
5 http://en.klimatilpasning.dk/media/665626/cph_-_cloudburst_management_plan.pdf .
6 Urban Life Account 2013.

The Copenhagen model will be applied in the ongoing climate-change adaptation projects throughout Copenhagen. It will also be used throughout the project phase as a dialogue and prioritisation tool, supporting decision-making processes in all stages of the project. The two sets of values will be given equal weight in project evaluations. The model acknowledges that biodiversity is the foundation on which all values depend and that it should therefore have priority in potential trade-offs with individual ecosystem services.

The Copenhagen model is also designed to support monitoring and evaluation of projects by acting as a tool for dialogue between developers, consultants and management. The expert group recommended that the authorities (i) create scenarios to describe how the public can be involved before, during and after projects, and (ii) establish a multidisciplinary urban nature forum where stakeholders can gather and share knowledge about nature-based climate-change adaptation.7

The Copenhagen climate-change-adaptation plan has been incorporated into all aspects of planning, including overall municipal planning, local plans and sectoral plans. The municipality continues to implement adaptation projects throughout the city. The adoption of the Copenhagen model is still ongoing.

More information:

http://en.klimatilpasning.dk/media/600858/130206_mapping_climate_change_final.pdf .

http://en.klimatilpasning.dk/media/665626/cph_-_cloudburst_management_plan.pdf .

C.5. THE MARITIME SPATIAL PLAN OF LATVIA

Ecosystems and their services were assessed as part of the development of the national maritime spatial plan (MSP) of Latvia in 2015-2016. The reason for this assessment was to (i) map areas that are important for provisioning ecosystem services, (ii) identify the impacts of different sea-use scenarios and spatial solutions in the plan on marine ecosystems and their services, and (iii) raise stakeholder awareness on the importance of ecosystem benefits and services. The results of the mapping and assessment of ecosystems and their services have been applied to the SEA of the draft plan. This SEA was conducted in parallel to the development of the plan, which has not yet been adopted. This case study is relevant to marine spatial planning (Chapter 5).

The first national MSP of Latvia was developed in 2015-2016 under the supervision of the Ministry of Environmental Protection and Regional Development. This development process integrated ecosystems and their services to (i) map areas that are important for provisioning ecosystem services in Latvian marine waters, (ii) identify the impacts of different sea-use scenarios and spatial solutions in the plan on marine ecosystems and their services, and (iii) raise stakeholder awareness on the importance of ecosystem benefits and services. The results

7 https://issuu.com/sla_architects/docs/bynatur_og_klimatilpasning_small .

of the mapping and assessment of ecosystems and their services have been applied to the SEA of the draft plan. This SEA was conducted in parallel to the development of the plan.

Latvia carried out a mapping and assessment of ecosystems and their services for its marine waters. The mapping and assessment included the country's internal marine waters, territorial waters and exclusive economic zone, covering a total area of 28 000 km². To map the marine ecosystem, pelagic and benthic habitats were considered. 26 benthic habitat types were mapped and used as a basis for mapping provisioning and regulating ecosystem services. However, pelagic habitats were not mapped due to a lack of information.

The selection of ecosystem services to be included in the assessment was based on data availability and local expert knowledge. Seven ecosystem services were considered: 2 provisioning services ('wild animals and their outputs' and 'wild plants, algae and their outputs'), 4 regulating and maintenance services ('bio-remediation by micro-organisms, algae, plants and animals', 'filtration by animals', 'maintaining of nursery populations' and 'global climate regulation') and 1 cultural service ('physical and experiential interactions'). These selected ecosystem services mostly correspond to potential services, except for 'wild animals and their outputs' which was based on the actual supply of this ecosystem service.

Methods for assessing the selected ecosystem services varied depending on the type of ecosystem service and on the available knowledge and data. Empirical assessments and spatial data on the supply of ecosystem services were available only for the two provisioning services. Data on fish landings of four commercial species (sprat, herring, cod and flounder) were used as a proxy to assess the flow of the provisioning service 'wild animals and their outputs'. These data were collected from fishery logbooks of Latvian fishermen. On the provisioning of red algae, qualitative data on the spatial coverage of the species was used. Benthic habitat types were used as a proxy to assess regulating and maintenance services, with a qualitative assessment made using a binary scale. For cultural ecosystem services, an indicator of marine tourism and leisure opportunities along the coast was developed based on expert advice and empirical data. Limitations arose from the lack of empirical survey data on habitat distributions, resulting in a low certainty level for the maps of regulating ecosystem services. A tiered approach was used to overcome data scarcity and limited human and time resources. However, the adaptive process used to draw up the MSP provides opportunities to increase data accuracy in the future.

Four alternative scenarios for the future were developed. These alternative scenarios looked at how different factors could affect Latvia's maritime environment. The factors covered the economy, society, environment, public policy and climate change. The four scenarios produced were: (i) a scenario focused on economic growth, (ii) a scenario focused on social well-being, (iii) a scenario focused on creating resilient marine ecosystems and (iv) a scenario that looked at the development of Latvia's marine waters within a common space of the Baltic Sea region. A strategic assessment of these scenarios by SWOT analysis was carried out during three coastal regional workshops with the active participation of stakeholders. An environmental impact assessment of the four scenarios was also carried out. This environmental impact assessment was qualitative, and used a multi-criteria analysis method covering economic, social, environmental and cross-border impacts. The criteria included: ecology, ship routes and infrastructure, recreational activities, safety in the military and renewable energy sector, port development, and marine-related entrepreneurship. Expert opinions were used to assess the possible impacts of the four scenarios against different components of marine ecosystems (benthic habitats, birds, fish, and marine mammals). This spatial assessment enabled the identification of optimum locations for different maritime activities, with a special consideration of new activities that were expected to cause damage, such as offshore wind farms and marine aquaculture farms. These spatial solutions were assessed repeatedly. However, it was difficult to analyse trade-offs during the assessment of scenarios due to knowledge gaps on the links between ecosystem conditions, ecosystems services and societal benefits.

Solutions for permitted sea-based activities were drawn up based on the following criteria: (i) compliance with environment and nature legislation, (ii) restriction of economic activity based on resource availability and/or the preservation of particularly sensitive or ecologically valuable areas, (iii) maintenance of ecosystem integrity and connectivity, and (iv) rational use of marine space and conflict minimisation.

The Latvian MSP process included a wide variety of techniques and tools to encourage stakeholder participation. These techniques and tools included public hearings, questionnaires and workshops. Information on the MSP was disseminated to the public to facilitate participation and raise awareness on the process. Various publications were also made available in English. A database was created to identify stakeholders by 'snowball' sampling, which enabled the identification of 440 stakeholders during the 16-month process. Among these stakeholders, a broad range of sectors was represented — mainly from local government, the shipping industry, and environmental policy organisations. But there was also representation from the security, fishery, energy, nature conservation, cultural heritage and tourism sectors.

The MSP also included the design of indicators to monitor its implementation. Monitoring will be based on the environmental indicator approach. Monitoring will also take into account marine-environment monitoring data, representative data on fish distribution and fishing resources, and other available information. The Latvian MSP was approved by parliament in 2017.

More information:

European MSP Platform (2018). The ecosystem-based approach in MSP — the Latvian recipe. Available at: *http://msp-platform.eu/practices/ecosystem-based-approach-msp-latvian-recipe*

Veidemane et al. (2017) Application of the marine ecosystem services approach in the development of the maritime spatial plan of Latvia, *International Journal of Biodiversity Science, Ecosystem Services & Management, 13(1)*, 398-411

C.6. DELIVERING WETLAND ECOSYSTEM SERVICES THROUGH CLIMATE-CHANGE-ADAPTATION STRATEGY IN THE ATTICA REGION, GREECE

Integration of ecosystem-service knowledge into climate-change-adaptation plans can improve the management and conservation of wetlands. This can ensure wetlands are able to continue providing multiple services. The climate change adaptation strategy for the Attica region of Greece commits to conserving Attica's wetlands and increasing their resilience by simultaneously improving the provision and management of ecosystem services. This case study is relevant to: the use of planning to support decision-making and stakeholder engagement (Chapter 3), policy for climate change (Chapter 4).

There are more than 100 wetlands in the Attica region of Greece, including estuaries, streams, coastal marshes, lagoons, lakes and constructed wetlands. Due to various human and economic activities, the area has become fragmented. The wetlands are small biodiversity islands in a degraded environment, which has a decreased capacity to provide ecosystem services.

In developing environmental policy guidelines at regional level, the Attica region focused on protecting wetland ecosystems from the impacts of climate change. By improved conservation measures and management of wetlands, significant benefits from ecosystem services are expected. These benefits include (i) the protection of the coasts by reducing the effect of waves and currents; (ii) the improvement of water quality by trapping sediments, nutrients and toxic substances; and (iii) support to economic activities that depend on wetland resources.

The strategy and action plan for wetland ecosystems in Attica (Greece) was produced as part of one of the pilot studies of the OrientGate project, which ran from 2012 to 2014. Co-funded by the South East Europe Transnational Cooperation Programme, the project aimed to implement concerted and coordinated climate-change-adaptation actions across south-eastern Europe. It planned to achieve this by building partnerships between organisations that produce knowledge and organisations that apply this knowledge in policy and territorial planning. The main objective of the project was to communicate up-to-date climate knowledge for the benefit of urban planners; nature protection authorities; regional and local development agencies; and territorial and public-works authorities. The project was coordinated by the Euro-Mediterranean Centre on Climate Change.

Future climate projections conducted in the OrientGate project indicated that wetlands would be increasingly vulnerable to drought due to the greater frequency and longer duration of drought episodes. Projections indicated that the impacts of this drought vulnerability would be exacerbated by human activities and inadequate operational capacity. The project investigation suggested that the agencies responsible for these wetlands had a medium-level of operational capacity. The project investigation also suggested that funds were available for the implementation of adaptation measures. The area suffered from inadequate protection and management due to (i) a lack of knowledge of wetland ecosystem services, (ii) insufficient experience in the use and interpretation of climatic information, (iii) an absence of networking, and (iv) a failure to exchange experiences and good practices.

Development of a climate-change-adaptation strategy: One of the OrientGate goals was to produce a climate-change-adaptation strategy and an action plan that would integrate climate knowledge, policy and planning. The goal was for the strategy and action plan to follow three priorities: (i) to monitor and assess the environmental quality of wetland areas in the Attica region, (ii) to study drought deterioration in the future, and (iii) to implement a series of measures that would reduce the vulnerability of regional wetlands to climate change. The foundations for the strategy were built using geospatial data, climatic parameters, wetland features, information from ongoing activities, and information from partners' scientific research.

The Environment Directorate of the Attica Regional Authority developed the strategy document in collaboration with the Greek Biotope Wetland Centre of Goulandris Natural History Museum, which provided scientific support. The strategy committed to conserve Attica's wetlands and increase their resilience by simultaneously improving the provision and management of ecosystem services. The strategy also contains an action plan, the main actions of which are:

(i) improving knowledge about climate change and its influence on species, habitats and ecosystem functions;

(ii) conservation actions, including wetland designation, better protection and restoration of wetlands, and the creation of green infrastructure;

(iii) sustainable use of natural resources through:

a. strict enforcement of measures to prevent and combat pollution,

b. investments to promote efficient and sustainable water use and treatment, and

c. land-use planning for conserving wetlands.

(iv) environmental interpretation measures, such as enhancing environmental awareness, development of information centres and other interpretation infrastructure, and promoting eco-tourism;

(v) improving governance by supporting environmental control mechanisms, training, networking and sharing of good practice; and

(vi) fostering support from industry (including encouraging the reduction of emissions and promoting best practices in entrepreneurship).

Priority actions of the action plan comply with the national operational plan for the environment 2014-2020, the national strategy and action programme on biodiversity, the master plan of Attica 2021, the RBMP for the Attica water district, and the operational plans of municipalities in the Attica region.

Role of stakeholder engagement: Various stakeholders engaged in the project from its early stages. Collaboration among local and regional authorities, environmental organisations, research institutions, and citizen initiatives was key in the strategy's development. Participative methods ranged from meetings and interviews to workshops and training seminars. A seminar entitled 'Adaptation strategy for Attica Wetlands: The assessment of the wetland vulnerability index' and an open dissemination event, which reached over 100 participants from various backgrounds. The project was also the subject of a Green Week 2015 satellite event with around 90 attendees, which opened a dialogue on implementation.

To facilitate the implementation of specific actions in the action plan, a road map was produced by the Attica Regional Authority. Since 2015, priority actions have been implemented by a project called 'Improving knowledge and increasing awareness for wetland restoration in the Attica region'. When the first stage of the strategy is completed in 2020, a second stage will be planned based on the outcome of the first stage.

More information:

European Climate Adaptation Platform

https://climate-adapt.eea.europa.eu/metadata/case-studies/wetland-adaptation-in-attica-region-greece-1
Attica region wetlands, Greece
http://atticawetlands.eu/
OrientGate project
http://www.orientgateproject.org/uploads/Press%20releases/results%20docs/pilot%20study%20reports/WP5_Pilot%20Study%204_Report_WEB.pdf

C.7. ECOSYSTEM-SERVICE MARKET FOR PEATLAND RESTORATION, THE UK

Development of voluntary standards for the private sector can help to create markets for peatland climate benefits. This could make peatland restoration attractive for business-sector sponsors. The UK Peatland Code demonstrates how such a framework can be developed and implemented through targeted science-policy research and pilot projects. This case study is relevant to: voluntary standards for the private sector (Chapter 3.2.3); market-based instruments, stakeholder consultation and engagement (Chapter 3); and business consideration of ecosystem services (Chapter 6).

The UK Peatland Code was designed to facilitate business sponsorship of peatland restoration, motivated by corporate social responsibility. The Peatland Code is a voluntary standard, which provides restoration projects with guidance on best practices and standard quantification methods to prove the climate benefits of peatland restoration. This makes peatland restoration attractive for sponsors through an open, credible and verifiable process. The Peatland Code was developed from 2011 to 2015 as part of a range of pilot research projects on payments for ecosystem services (PES) funded by the Department for Environment, Food and Rural Affairs (Defra) of the United Kingdom. The standard is issued by the UK National Committee of the International Union for the Conservation of Nature (IUCN) and is managed by an executive board. The standard is also assisted by the IUCN's UK Peatland Programme and supported by a technical advisory board.

The launch of the UK Peatland Code was encouraged by Defra's Natural Environment White Paper, published in 2011. Further encouragement for the launch came from the subsequent formation of an Ecosystem Markets Taskforce to investigate business opportunities in the natural environment. The Taskforce recommended that a robust peatland carbon code be developed, and a partnership between Defra and the IUCN UK Peatland Programme was declared in Defra's 2013 action plan for developing the potential of PES. The action plan acknowledged the Peatland Programme's work over the previous years. The target of 1 million ha of peatlands to be in good condition or under restoration management by 2020, suggested by the IUCN UK Commission of Inquiry on Peatlands, would meet the targets in the UK biodiversity action plan for blanket and raised bog restoration, and could reach an abatement potential of 2.5 million tonnes of CO_2 equivalent per year.

A pilot research project called the Peatland Carbon Code was conducted by Birmingham City University in 2012 and 2013. The research project had a budget of £23 613 to perform necessary research for the creation of a market scheme to sponsor peatland re-wetting and restoration across the UK. The research was concluded with the launch of the Peatland Code pilot phase. Although the primary focus of the research project was the benefits of carbon and climate-change mitigation, the whole range of peatland ecosystem services was acknowledged in the drafting of the Code. These benefits included water quality and water regulation; reduced flooding and wildfire risk; recreation opportunities; and the provision of habitats for wildlife. Safeguards were recommended to tackle trade-offs between ecosystem services through (i) proactive land management planning and mitigation measures or (ii) additional payments as compensation for lost income (where restoration requires reduced intensity of livestock grazing).

Actions conducted within the pilot research project and the drafting of the Code consisted of: (i) market research; (ii) formulating principles for peatland PES and dealing with technical issues; (iii) developing guidance on contracts and monitoring; and (iv) identifying opportunities for combining the carbon sequestration payment schemes with additional PES schemes, such as those on water quality. The subsequent 18-month-long pilot phase aimed to test the scheme, build the evidence base and demonstrate the benefits. The intention of this pilot phase was to further develop the Code by (i) testing and refining proxy models for carbon monitoring and developing a standardised field protocol for vegetation monitoring, (ii) developing evidence-based financial analysis of the various life-cycle costs associated with investing in peatland restoration, and (iii) working with the UK Accreditation Service and accredited third-party auditors to develop protocols to assess projects under the Peatland Code.

Business sponsorships of peatland restoration are expected to cover the full costs of restoring peatland including maintenance. These costs vary depending on the peatland type, degradation level, location, and benefits. The mid-range of costs is GBP 550-2 000 per hectare. Eligible projects must be transparent, well-documented, and be of high environmental quality. These projects must involve effective monitoring of carbon benefits, which may be carried out through vegetation proxies or by direct empirical measurements. Each project must undertake a risk assessment of the reversibility of the project benefits. Concerns about contract length and the failure of restoration works were indicated to be the main obstacles preventing the participation of private landowners. On the other hand, institutional beneficiaries such as NGO landowners proved to be efficient in delivering the restoration projects at relatively low cost. This suggests that opportunities should be further explored to promote the cooperation of NGOs and private landowners.

For investors, the research findings showed there was interest for a regional sponsorship scheme motivated by corporate social responsibility targets. This interest was helped by the identification of sponsors with the associated projects, and by the prospective benefits that peatland restoration would bring to their businesses or to the marketing of their products. These businesses interested in sponsorship were mostly from the food and drink, tourism, energy, water and horticulture sectors. They were primarily interested in the carbon benefits of peatland restoration, but were also interested in water quality and biodiversity. The research showed that the provision of these co-benefits does not necessarily require quantification, and can be founded on the credible evidence specific to the site, based on trust towards the project team. In its current version, the Code only provides assurance on the climate benefits of peatland restoration; the other co-benefits can be reported independently. Additionally, integration of co-benefits such as water quality or biodiversity may allow for a higher sponsorship price, which would enable funds to be raised for restoring heavily degraded or remote sites.

Stakeholder consultation and engagement: The development of the Code was supported by the latest research evidence. Various stakeholders were included in the development of the Code through (i) international expert workshops, (ii) feedback from the Code steering group, and (iii) input from individuals and organisations across the UK. Representatives of small-to-medium-sized businesses and companies were interviewed, and investors were engaged in designing the marketing strategy. The Technical Advisory Board of the Code includes additional stakeholder groups when required. A campaign was held to raise awareness of the Code, the corporate social responsibility principle, and the climate-change-mitigation benefits of peatland restoration. Some sponsors were keen to learn about the Code's potential for carbon offsetting. However, the Peatland Code's carbon units cannot currently be used for carbon offsetting or in the international carbon market.

A draft UK Peatland Code was published in June 2013 and a Peatland Code pilot phase was launched in September 2013, with pilot restoration projects in England and Wales. In 2015, a Peatland Code 1.0 was released as a conclusion of the pilot phase. The Peatland Code 1.0 was aligned to a new report 'Developing Peatland Carbon Metrics and Financial Modelling', which facilitated the quantification and valuation of the carbon impacts of peatland restoration. A Peatland Code 1.1 (launched in 2017) is now in operation to validate projects.

Besides the Code development, the research provided valuable insights on other opportunities and schemes for PES beyond peatland ecosystems and the UK. With the Peatland Code in place, the UK became a front-runner in the PES agenda in Europe and interest in the Code development process was shown from bodies such as the European Network of Heads of Nature Conservation Agencies and Germany's Federal Agency for Nature Conservation.

More information:

Towards the development of a UK Peatland Code, Final Report (2013)

http://randd.defra.gov.uk/Document.aspx?Document=11658_DefraPESPilotPeatCodeFinalReport2.pdf

Peatland Code: pilot phase final report (2015)

http://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/Peatland%20Code%20Pilot%20Phase%20Evaluation%20Report%20%28final%29.pdf

IUCN UK Peatland Programme

http://www.iucn-uk-peatlandprogramme.org/peatland-code

Investing in nature: Developing ecosystem service markets for peatland restoration. Ecosystem Services (2014)

https://www.sciencedirect.com/science/article/pii/S2212041614000692

C.8. GREEN URBAN INFRASTRUCTURE STRATEGY FOR VITORIA-GASTEIZ, SPAIN

Urban green infrastructure plans help improve ecosystem services to support both human well-being and conservation objectives. The Vitoria-Gasteiz green urban infrastructure strategy shows how green infrastructure planning can support the supply of ecosystem services and improve ecological connectivity in an urban and peri-urban setting. This case study is relevant to: (urban) spatial planning, linking with protected areas management plans and the role of funding (Chapters 3 and 4).

Vitoria-Gasteiz is the capital city of the Basque Autonomous Community (in northern Spain) and of the province of Alava. The city is located in the southern part of the Atlantic biogeographical region, and has a population of more than 250 000 inhabitants. In the future, changes in precipitation patterns, an increase in temperature, and an increased risk of flooding are expected in the region.

The Vitoria-Gasteiz green urban infrastructure strategy is governed locally. It was launched in 2012 by the city council to provide a wide range of ecosystem services, such as biodiversity enhancement, climate-change mitigation, and climate-change adaptation. The strategy is closely linked to the city's biodiversity conservation strategy and its plan to combat and adapt to climate change. The biodiversity conservation strategy specified the need to carry out a green urban infrastructure strategy, and also established the priority 'elements' or features it would need to have to ensure ecological connectivity. Connectivity between urban and peri-urban areas was specifically planned for in the green urban infrastructure strategy. In addition, the plan to combat and adapt to climate change required a green urban infrastructure strategy that would provide guidelines to develop and consolidate a green network in the city. There were also implicit synergies between (i) the green urban infrastructure strategy and (ii) the objectives of the sustainable mobility and public space plan, the health plan and the city's energy strategy.

The Vitoria-Gasteiz green urban infrastructure strategy seeks to achieve the following objectives:

(i) the improvement of biodiversity in the city through an increase in the spatial and functional connectivity between urban and peri-urban green areas;

(ii) an increase in urban ecosystem services and the strengthening of natural processes;

(iii) the consideration of ecological and hydrological processes and flows in urban planning;

(iv) a reduction of the urban 'heat island' effect and climate change impact, as well as an improvement of climate-change-adaptation measures;

(v) support for the public use of green spaces, increase in leisure/recreational opportunities, more accessible green spaces and countryside-city connections, preservation of cultural heritage and traditional landscapes, and a greater sense of identity and belonging among residents;

(vi) the creation of an urban environment that supports the health, well-being and general liveability of the city;

(vii) to raise awareness of the relationship between nature/biodiversity and society, and in particular, to raise awareness of the goods and services provided by ecosystems (including their economic valuation);

(viii) to contribute to economic development through job creation.

Role of ecosystem-service assessment: No dedicated ecosystem assessment was carried out to support the development or implementation of the strategy. However, a process consisting of expert engagement and a literature review was carried out. Policy formulation for the strategy was based on the expert knowledge of the Vitoria-Gasteiz municipal staff and the Centre for Environmental Studies. It was also based on bibliographical resources such as the information provided by the European Commission. Information generated from projects such as the Central Superblock of Vitoria-Gasteiz (in which the use of public space was reclassified according to the needs of different mobility typologies) and the mobility and public space plan was also used. The sustainable mobility plan of Vitoria-Gasteiz proposed to divide the city into several 'superblocks'. The sustainable mobility plan provided a framework to assess and plan the final design and implementation of each superblock. The framework integrated the design and implementation works with other measures that were proposed to improve mobility in the city (such as the assessment and implementation of a new public transport network; restrictions on access to the city centre; and the assessment and implementation of a new network of pedestrian and bicycle lanes).

Role of indicators and scenarios: The outcomes of an assessment of 50 indicators, coupled with spatial modelling tools, provide a useful reflection on the implementation of the strategy. Indicator values were produced for three scenarios — the current situation and two potential future scenarios (2020 — stage 01 and 2050 — stage 02). The indicators were divided into the following components: 'occupation of the soil', 'public space and habitability', 'mobility and services', 'urban complexity', 'urban metabolism', 'green spaces and urban biodiversity', and 'social cohesion'. Examples of indicators used include 'absolute (urban) compactness', 'variation of the index of habitability', 'percentage road area for pedestrian use', 'environmental comfort in public space' and 'proximity to alternatives to the network of transport by private motor vehicles'. These indicators helped identify sustainability issues that required the adoption of measures in the city.

Role of existing policy instruments: The policy framework on which the green urban infrastructure strategy is based is the 2003 general plan of urban planning (PGOU), which is currently under review due to changes in the socio-political and urban situation. In addition, the PGOU has to adjust to legal changes introduced in the Basque Country (Ley del Suelo y Urbanismos 2/2006), which changed the urban development and planning model in the region. The green infrastructure strategy adopted at EU-level in 2013 — which aims at the protection, restoration, creation and improvement of green infrastructure — was also incorporated in the city strategy.

Role of dedicated financing: Public investment was used to launch the green urban infrastructure strategy in Vitoria-Gasteiz. This public investment consisted of regional funds provided by the Basque Country administration and by the city of Vitoria-Gasteiz's own funds. However, to develop a comprehensive city strategy that would create synergies with other plans, a wide range of additional funds were secured. For instance, two sources of funding were used for the mobility plan and the public space plan: (i) city funds from a 2009-2011 project called the Alhondiga plan to support small retailers (this programme focused on the development of some parts of the city and served as pilot superblocks), and (ii) funding allocated to cope with the global economic crisis (to boost the economy, the Spanish government allocated a significant budget for public works for the period 2009-2010; however, due to the effects of the economic crisis, these funds were not extended in subsequent years).

The city of Vitoria-Gasteiz has not yet developed direct indicators to measure the results of the city's green urban infrastructure strategy. This is mostly because the benefits of the strategy are often difficult to measure and mostly relate to long-term objectives. However, some monitoring projects are under development. Examples of monitoring projects under development include: the creation of a monitoring programme on urban common birds, water-consumption monitoring in green areas, an assessment of urban trees acting as CO_2 sinks, cost-benefit studies on greening actions, the creation of an exotic invasive species inventory, and an evaluation of the carbon footprints of green areas. It is expected that the development of these indicators will help promote supportive adaptive management.

More information:

Implementation of the Vitoria-Gasteiz Green Urban Infrastructure Strategy (2018)

Environmental studies centre: the green infrastructure of Vitoria-Gasteiz

C.9. ECOSYSTEM SERVICE MAPPING AND ASSESSMENT TO SUPPORT THE URBAN PLAN OF TRENTO, ITALY

Urban green infrastructure plans help improve ecosystem services to support both human well-being and conservation objectives. The urban plan of Trento, Italy, shows how ecosystem-service mapping and assessment can support urban planning. This case study is relevant to: ecosystem-service assessment following the EU MAES framework, and (urban) spatial planning and stakeholder engagement (Chapters 3 and 4).

Trento is an Alpine city of 120 000 inhabitants in north-eastern Italy, roughly halfway between the Brenner Pass and the Adriatic Sea. The main settlement, where 70 % of the city's population lives, is located along the Adige river's valley floor at an elevation of 194 m above sea level. The remaining 30 % lives in small villages spread in the surrounding hills and mountains. Agricultural areas (mainly vineyards and apple orchards) occupy parts of the hills and the few non-urbanised patches on the valley floor. Forest covers most of the remaining municipal territory, which spreads over more than 150 km^2, and up to an elevation of 2 180 m. More than 10 km^2 of the municipal territory is designated as natural protected area, including seven Natura 2000 sites and three local reserves. This means that human settlements are very close to green areas and natural environments.

The role of ecosystem-service mapping and assessment: In 2017, the municipal administration started drafting a new urban plan for the city of Trento. During this process, which is still ongoing, researchers from the University of Trento were employed to carry out an urban ecosystem-service assessment, and to propose ways to include the outcomes of the assessment in the planning process. The overall purpose of the assessment was to improve the provision of ecosystem services and related benefits through the actions and instruments of the urban plan. The assessment sought to address two specific policy questions: (i) how can knowledge of ecosystem-services make it easier to identify the structural elements of the urban plan, and (ii) how can ecosystem-service assessment support the comparison of specific planning options.

The urban-biodiversity benefits and ecosystem services included in the assessment are: habitat provision for focal species, hydrogeological risk mitigation, noise and air-quality regulation, food supply, microclimate regulation, and nature-based recreation. The assessment of most of the selected ecosystem services was based on spatial proxies or simple modelling. However, more detailed analyses were conducted for microclimate regulation and nature-based recreation due to their relevance for Trento. The selection of microclimate regulation was due to the growing concerns about summer heat waves, which are particularly intense in the city due to air stagnation in the valley floor. The most urbanised and sealed part of the city is particularly exposed to this problem. This causes peaks in energy demand and poses serious threats to public health and well-being. The selection of recreation was due to the specific planning objectives of the city administration, which were to improve public green areas and provide equal opportunities to the public for recreation and relaxation.

The mapping and assessment of the cooling capacity (microclimate regulation) of urban green and blue infrastructure was performed using a method specifically designed to support planning and management decisions at the urban and sub-urban scale (Zardo et al., 2017). The method involved an analysis of the effects of shading and evapotranspiration, by considering the soil cover, canopy coverage and size of green areas. The mapping and assessment of the potential and opportunities for nature-based recreation in the city was carried out by adapting existing recreation modelling to reflect the specific context of Trento. The approach combined indicators based on the availability and accessibility of nature-based recreational areas, and considered urban parks and nearby natural areas (forest, mountains, etc.) (Cortinovis et al., 2018).

Engagement with stakeholders: The urban ecosystem-service assessment was carried out in close collaboration with key staff from the city's planning department, which helped draw up the policy questions, select the ecosystem services to be studied, and provide feedback on the results. The outcomes of the assessment are periodically discussed in a wider science-policy working group organised by the local administration to discuss emerging issues in the drafting of the new urban plan. The working group includes academics, local practitioners from various disciplines, and representatives of NGOs and the general public. Experts were consulted to assess nature-based recreation in the city. Seventeen experts (including officers from several municipal and provincial departments, researchers from various institutions, and local practitioners) were involved through an online questionnaire and a follow-up discussion.

Answers to the first policy question (how can knowledge of ecosystem-services make it easier to identify the structural elements of the urban plan?) are being provided through an urban ecosystem-services assessment. This urban ecosystem-services assessment was recently completed, and was based on an analysis of the current provision of ecosystem services by green and blue infrastructure. This analysis led to the identification of 'ecosystem service hotspots', i.e. areas that are instrumental to ensuring a high level of ecosystem services. These ecosystem-service hotspots will become part of the 'structural elements' of the urban plan, along with more traditionally recognised elements, such as protected areas, areas subject to hydrological risk, etc. The inclusion of 'ecosystem-service hotspots' among the structural elements of the urban plan ensures that urban green and blue infrastructure is considered as a primary component of the urban system in the design of the plan. The 'hotspots' will be preserved from urbanisation, and different actions are now under consideration to improve the current network of green and blue spaces. This will increase both connectivity and the provision of ecosystem services.

Answers to the second policy question (how can ecosystem-service assessment support the comparison of specific planning options?) were supported by a more detailed urban ecosystem-services assessmentin 2018, which also considered the demand for ecosystem services by the general public. This will be used for the identification, for example, of disadvantaged neighbourhoods, and to suggestions for different types of actions to satisfy current and future demand. One example of the approach can be seen in a comparison that was made of different greening interventions in brownfield sites (Geneletti et al., 2016). Scenarios were assessed by quantifying the expected benefits from the different interventions on the surrounding population. Different groups of beneficiaries were considered in different scenarios, leading to different recreation needs or different levels of vulnerability to heat waves. Similar scenario analyses will be conducted during the remaining part of the planning process to support decisions about land-use changes and allocations.

The results of the more detailed ecosystem-service assessment will form the basis for the formulation of specific requirements for future urban transformations. These requirements will be site-specific and aim at both safeguarding the current provision of key ecosystem services, and enhancing their provision in areas of the city where they are most needed. These goals will be pursued by designing specific performance-based indicators and compensation schemes.

More information:

Cortinovis, C, Geneletti, D (2018) Mapping and assessing ecosystem services to support urban planning: a case study on brownfield regeneration. One Ecosystem.

Geneletti, D., Zardo, L., Cortinovis, C. (2016) Promoting nature-based solutions for climate adaptation in cities through impact assessment. In: Geneletti, D (Ed). Handbook on biodiversity and ecosystem services in impact assessment, Edward Elgar Publishing, 428-452.

Zardo, L., Geneletti, D., Pérez-Soba, M., & Van Eupen, M. (2017). Estimating the cooling capacity of green infrastructures to support urban planning. Ecosystem Services, 26, 225-235.

C.10 DEVELOPMENT OF A NATIONALLY ENDORSED ECOSYSTEM-ACCOUNTING FRAMEWORK, THE NETHERLANDS

A framework for ecosystem accounting can provide information on the amount and location of ecosystem services, forming a comprehensive basis for spatial planning at national level. The Netherlands is pioneering the implementation of the System for Environmental Economic Accounting - Experimental Ecosystem Accounting (SEEA-EEA) framework on a national scale. This framework is intended to serve as a supplement to national accounts. This case study is relevant to: natural capital accounting (Chapter 3) and spatial planning (Chapter 4).

The Netherlands has a nationally endorsed, ecosystem-accounting framework based on the System for Environmental Economic Accounting - Experimental Ecosystem Accounting (SEEA-EEA) framework. It is one of the first countries in the world to start the implementation of SEEA ecosystem accounting on a national scale, as a supplement to its national accounts.

In 2016, Statistics Netherlands and Wageningen University began a three-year project to test and implement an SEEA-EEA ecosystem-accounting framework for forest and heathland areas in the Netherlands. The framework being tested includes thematic accounts for carbon and biodiversity to understand how these contribute to the Dutch economy and society. The objectives of the project are to develop and compile land accounts (covering land use and land activity) for the Netherlands and carry out an inventory of available data for the Netherlands on ecosystem services, ecosystem assets and ecosystem condition.

The spatial delineation of ecosystem types is the basis of all ecosystem accounts. Each spatially delineated ecosystem unit produces a certain set of ecosystem services and products, the amount of which depends on the size (extent) of the unit and its condition. Therefore, the project is developing a highly detailed map showing ecosystem units in the Netherlands and an economic users map (to identify the economic users of location-specific services).

The project has developed a method for the monetary quantification of the services that ecosystems provide. This will make it easier for policymakers to value and compare ecosystems in a way that is consistent with the national accounts. High-resolution land-cover ecosystem-unit maps have been developed, as have tables for the physical supply and use of 15 or more ecosystem services. These land-cover maps are categorised according to six main land-cover themes: agriculture, dunes and beaches, forests and other (semi) natural and unpaved terrain, marshes and floodplains, water, and paved and built-up land. The maps serve as a basis for determining areas and changes to the ecosystem services in those areas. All the data on natural capital are processed into digital maps, which enables users to zoom in on a region in great detail. This will help to 'mainstream' natural capital into development planning and into national economic-accounting systems.

A pilot for ecosystem accounting in the Dutch province of Limburg is reporting on the physical supply of ecosystem services, ecosystem-condition indicators, and the monetary valuation approach. Examples from Limburg and Bonaire show that the previously unknown value of natural capital extends into the hundreds of millions of euros. In the Dutch province of Limburg, the monetary value of a range of ecosystem services was around EUR 112 million in 2010, with an average value of EUR 508 per hectare. The ecosystem services with the highest values were crop production, nature tourism and fodder production. More than 10 different ecosystem services on Bonaire (Caribbean) are estimated to have a total economic value of USD 105 million per year. This value, and its underlying components, can be used to build a strategy for effective conservation measures.

The carbon account, which provides a comprehensive overview of all relevant carbon stocks and flows, was published in September 2017. It can be used to meet the more detailed requirements on carbon-emissions reporting to the EU as of 2020, which are required as part of the Effort Sharing Regulation. The carbon accounts clearly illustrate the heavy dependency on fossil fuels in the Netherlands, and the difficulties of replacing fossil fuels with renewable energy from national biomass sources. Carbon emissions to the atmosphere by far exceed carbon sequestration rates, resulting in a net positive balance for carbon in the atmosphere. At present, Dutch ecosystems are a source rather than a sink for carbon. Although carbon sequestration is significant in forests, meadows and natural grasslands, the total annual sequestration of carbon in biomass is currently exceeded by the emissions from peat and peaty soils.

The ecosystem part of the carbon account-maps depicts where carbon emissions take place and which areas are most important for carbon sequestration. This facilitates climate action by provincial and local stakeholders, for example to mitigate the effects of drained peatlands. In addition, the indicator that tracks the trend in the net flows of geocarbon plus the import of geocarbon is useful for indicating progress towards a circular economy. Showing the total carbon stock per carbon reservoir provides insight about potential future flows that depend upon policy choices. Finally, SEEA, as the most comprehensive method for natural capital accounting, contributes to any climate-change mitigation strategy by encouraging greater long-term sustainability and economic efficiency in the use of natural resources.

Dutch accounts for biodiversity and the condition of ecosystems will be developed over the course of 2018 and 2019.

Once completed for the Netherlands, and for a broad set of ecosystem services, the supply accounts will provide information on the amount and location of supplied ecosystem services. This will give an insight into the wide range of services that are offered primarily by natural and semi-natural vegetation, and it will show the locations of the supplied services in detail. The spatial information can then be used to optimise the current use of ecosystem services, and to determine where changes are most needed to protect or optimise ecosystem service supply.

More information:

https://seea.un.org/news/ecosystem-accounting-netherlands,

https://www.cbs.nl/nl-nl/corporate/2017/35/waarde-bos-heide-en-bebouwde-grond-in-kaart-gebracht

https://kenniskaarten.hetgroenebrein.nl/en/knowledge-map-natural-capital/value-natural-capital-netherlands/

https://www.unenvironment.org/news-and-stories/story/towards-natural-capital-accounting-netherlands

https://www.cbs.nl/en-gb/background/2017/12/ecosystem-unit-map

https://www.cbs.nl/achtergrond/2017/45/the-seea-eea-carbon-account-for-the-netherlands

C.11. CAPACITY BUILDING FOR INTEGRATING ECOSYSTEM SERVICES INTO REGIONAL DEVELOPMENT POLICIES ACROSS THE EU

EU funding can support capacity building and the establishment of science-policy structures needed for the integration of ecosystem services into regional development policies. The BID-REX projects bring together seven European regions to improve the integration of biodiversity and ecosystem services into existing policy instruments. This case study is relevant to: EU funding (Chapter 5); the integration of ecosystem service information into the policy cycle, capacity building, and awareness raising (Chapter 3); and spatial planning (Chapter 4).

The project ‘From biodiversity data to decisions: enhancing natural value through improved regional development policies’ (or ‘BID-REX’ for short), is a two-phase, five-year project, funded by Interreg Europe. It began in 2016. BID-REX is a partnership that brings together nine organisations from seven European regions (Catalonia (Spain), the Basque Country (Spain), Norfolk (UK), Marche Region (Italy), Ljubljana Marsh (Slovenia), the North Great Plain Region (Hungary), and Wallonia (Belgium)) across six countries. Five of the project partners are public authorities (the Government of Catalonia; the Basque Government; Norfolk County Council; the Marche Region; and the Public Service of Wallonia), and four are research institutions (the Forest Sciences Centre of Catalonia in Spain, the University of East Anglia in the UK, as well as the National Institute of Biology and the University of Debrecen in Hungary.

The project seeks to protect and enhance natural capital by strengthening and improving regional development policies. It aims to achieve this by creating or improving the links between the use of quality biodiversity data and conservation-related decision-making. By promoting greater use of biodiversity information in decision-making, BID-REX hopes to increase the impact of the European Regional Development Fund (ERDF) across Europe.

One of the major challenges for the project is to encourage the prioritisation of biodiversity conservation efforts in ERDF funding allocations. The project hopes this can be achieved by demonstrating how appropriate, and evidence-based biodiversity and environmental information can improve decision-making processes.

Phase one of the project, which runs from 2016 to 2019, has brought the project partners together as part of an interregional learning process. This first phase centres on five interregional thematic workshops. The themes of these workshops are:

- information needs for decision makers;
- matching information to needs;
- improving data flows;
- capacity building for decision makers and data providers; and
- a discussion on how the learning process has impacted the partners' action plans.

These workshops provide an opportunity for the project partners and associated stakeholders to exchange knowledge and experience on how to integrate biodiversity information and policy delivery. Project partners, each representing their specific regions, have also launched local learning processes. This local approach provides targeted opportunities to convene local stakeholders at meetings, workshops, and site visits to share best practices and experience on the successful use of tools and methods.

The output from the learning process in phase one will be a guidance document collating the experience and lessons learnt from the partners in their regions (as presented and shared in the interregional thematic workshops). This will set out how to obtain and use biodiversity data to increase the impact of allocated funds for European natural heritage preservation. It is hoped that this guidance will improve stakeholders' skills in the management of biodiversity information, which will in turn benefit the general public through improved ERDF allocations and the resulting preservation of natural heritage.

Each of the seven project regions has identified a policy instrument, network or site that it will seek to improve. These instruments and sites are listed in the bullet points below.

- The Catalan ERDF operational programme 2014 – 2020, Axis 6: Protecting the environment and promoting resource efficiency. Strategic objectives 6.3.2 & 6.4.2.

- The ERDF operative programme for the Basque Country, PO6: 'Conserve and protect the environment and promote resource efficiency'.

- The ERDF 2014-2020 programme for Norfolk County, England. Priority axis 6: Preserving and protecting the environment and promoting resource efficiency. Investment priority 6d: Protecting and restoring biodiversity and soil and promoting ecosystem services, including Natura 2000 and green infrastructure.

- The Marche region ecological network.

- The Regulation on Ljubljana's Marsh Nature Park.

- The Hungarian environment and energy efficiency operational programme 2014 – 2020.

- The regional policy statement for Wallonia 2014-2019.

Each region will produce a regional action plan in phase one. These will detail how lessons learnt from the interregional thematic workshops can be implemented to improve the corresponding policy instruments in the bullet points above. In consultation with project partners and local stakeholders, these action plans will be reviewed to ensure they adequately set out both their biodiversity-data needs and the associated activities for satisfying these needs.

Phase two of BID-REX will run from 2019 to 2021. It will focus on implementing the knowledge gained during phase one (and captured in the regional action plans) to improve policy.

To significantly improve the targeted policy instruments by implementing the regional project action plans, a number of changes are expected to be made. These changes will be made through a number of sub-objectives, namely:

- the identification of regional strengths and weaknesses in the use of biodiversity data;

- the identification, exchange, and implementation of best practice in biodiversity data and information management, and the use of this biodiversity data at different stages in decision-making processes;

- the improvement of local governance by (i) creating and improving discussion fora, (ii) developing synergies, and (iii) coordinating official visits among relevant regional stakeholders;

- increasing the technical capacity of regional stakeholders to manage biodiversity information and data flows;

- the improvement of workflows to create better decision-making and prioritisation (this will ensure better regional development policies, particularly those policies that use ERDF funding);

- increasing the social acceptance and credibility of decision-making processes derived from the use of objective and reliable information.

The project's impact will be monitored via four results-based indicators:

- the number of Growth & Jobs or European Territorial Cooperation (ETC) programmes addressed by the project;

- the number of other policy instruments addressed by the project;

- the estimated amount of Structural Funds (from Growth & Jobs and/or ETC) mobilised by the project (in EUR);

- the estimated amount of other funds mobilised (in EUR).

The total budget for the project is EUR 1.6 million, 85 % of which is funded through the ERDF, with the remainder being provided as co-funding from the project partners.

More information:

Project website: www.interregeurope.eu/bid-rex/

C.12 INTEGRATING ECOSYSTEM SERVICES INTO STANDARDS FOR PRIVATE INVESTMENT BY THE INTERNATIONAL FINANCE CORPORATION

Environmental and social (E&S) performance frameworks are often used in private financing. These frameworks provide a good framework for ecosystem-service integration. The International Finance Corporation's (IFC) environment and social performance standards recognise that protecting and conserving biodiversity, maintaining ecosystem services, and managing living natural resources appropriately are key to sustainable development. This case study is relevant to: private sector consideration of ecosystem services (Chapter 6); corporate ecosystem-services review and voluntary guidance to private sector, market-based instruments, and stakeholder consultation and engagement (Chapter 3).

The International Finance Corporation (IFC)— a sister organisation of the World Bank — is the largest global development institution focused exclusively on the private sector in developing countries. The IFC E&S performance standards set out the responsibilities of IFC clients for managing their environmental and social risks. The IFC's sustainability framework, which includes the performance standards, applies to all investment and advisory clients whose projects go through the IFC's initial credit review process.

The IFC recently looked at the performance of 656 companies in their portfolio, and found that companies with good E&S performance tended to outperform clients with worse E&S performance in return on equity and return on assets.

The IFC's E&S performance standard 6 recognises that protecting and conserving biodiversity, maintaining ecosystem services, and managing living natural resources appropriately are fundamental to sustainable development. This performance standard helps clients to sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout their project's life-cycle. Its objectives are:

- to protect and conserve biodiversity;
- to maintain the benefits from ecosystem services;
- to promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

The performance standard contains a process for identifying risks and impacts. Based on this process, the requirements of this performance standard are applied to projects (i) located in modified, natural, and critical habitats; or (ii) that potentially impact on, or are dependent on, ecosystem services over which the client has direct management control or significant influence; or (iii) that include the production of living natural resources (e.g. agriculture, animal husbandry, fisheries, forestry). As part of an environmental and social management system, client companies must adopt a verification process to evaluate their suppliers of primary products. This is to demonstrate that raw materials are not being purchased from sources where there is significant damage to natural and/or critical habitats.

Development of good-practice guidance: Deforestation and habitat conversion is overwhelmingly the most significant driver of biodiversity and ecosystem loss associated with agro-commodity production. The IFC Good Practice Handbook for the agro-commodity supply chain guides companies on conducting sustainable business in a variety of industries (for example, the primary supply chains for palm oil, soy, cacao or coffee). The more information that is available about the origin of primary production, the easier it becomes to make informed decisions about which supply chains to work with and when to remove non-conforming products and suppliers. For this reason, IFC clients engaged in the primary production of living natural resources must comply with a credible certification scheme. The Good Practice Handbook also encourages other clients to implement certification to manage the environmental and social risks in their supply chains. Some leading international examples of relevant certification schemes include the Roundtable on Responsible Soy, the Roundtable on Responsible Palm Oil, the Rainforest Alliance, Fairtrade, and UTZ.

The more complex a business, the greater the potential risk it faces. For example, an international commodity trader might purchase 15 agro-commodities from around the world and be involved in all stages of the supply chain, including primary production, processing, and ingredient manufacturing. For high-risk commodities, there are a number of management strategies such a trader could follow:

- the implementation of supply chain mapping and continuous monitoring to (i) identify source countries, (ii) work towards traceability, and (iii) determine leverage characteristics;

- the purchase of products certified under acceptable schemes where available;
- field evaluations of owned plantations using appropriate criteria;
- implementation of supplier-engagement strategies and pre-financing linked to sustainability requirements (for commodities with a smallholder supply base).

Use of a corporate ecosystem-services review: Companies often fail to make the connection between the health of ecosystems and the business bottom line. These companies are not fully aware of the extent of their dependence and impact on ecosystems and the possible effects of their operations. The corporate ecosystem-services review, promoted by the World Resources Institute and the World Business Council for Sustainable Development, builds on the IFC E&S performance standard 6 and is designed to address these gaps. It consists of a structured methodology that helps managers develop strategies to manage business risks and opportunities arising from their company's dependence and impact on ecosystems. It is a tool for strategy development, not just for environmental assessment.

Examples that show how the standard has been applied can be found in the work of the World Business Council for Sustainable Development, such as the Cement Sustainability Initiative (CSI). The CSI is a global effort by 24 major cement producers with operations in more than 100 countries who believe there is a strong business case for the pursuit of sustainable development. Together these companies account for around 30% of the world's cement production, and they range in size from very large multinationals to smaller local producers. The CSI has developed a document to guide the preparation of an environmental and social impact assessment. The document reflects international good practice and promotes compliance with the IFC performance standards. Operators in the cement and aggregates industry are encouraged to use the guidance to inform the development of an environmental and social impact assessment. These environmental and social impact assessments are often required to secure governmental permission for the implementation of new investments and the expansion of existing operations. The assessment takes into account typical changes that arise during the development and operation of cement manufacturing facility, such as (i) clearance of vegetation that may lead to soil erosion, (ii) changes to the availability and quality of surface water, (iii) changes to groundwater flow, and (iv) impacts on plant and animal species and critical habitats in the area.

More information*:*

https://www.ifc.org/wps/wcm/connect/bff0a28049a790d6b835faa8c6a8312a/PS6_English_2012.pdf?MOD=AJPERES

https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_handbook_agrosupplychains

http://www.wri.org/publication/corporate-ecosystem-services-review

http://wbcsdcement.org/index.php/35-key-issues/key-issues-biodiversity/385-biodiversity-management-planning-guidance-reference-list http://wbcsdcement.org/pdf/Guidelines%20for%20Environmental%20&%20Social%20Impact%20Assessment.pdf

C.13. CLIMATE BONDS TO SUPPORT THE ESTABLISHMENT OF GREEN SPACES IN PARIS, FRANCE

Climate bonds are a possible way to increase the number of green urban areas, promoting both conservation objectives and well-being. In Paris, 3.4 hectares of green spaces were created and close to 2200 trees planted between late 2015 and early 2017. It is estimated that these trees will sequester 1 600 tonnes of CO_2 during their lifetime. This case study is relevant to: business sector consideration of ecosystem services (Chapter 6), market-based instruments (Chapter 3), and spatial planning (Chapter 4).

In November 2015, the city of Paris issued its first climate bond to mobilise finance from the private sector for its sustainability programme. The total amount raised was EUR 300 million, and the bond must be repaid in May 2031. The money was to be devoted to financing projects that help tackle climate change in four categories: (i) reducing greenhouse gas emissions, (ii) reducing energy consumption, (iii) producing renewable energy and energy from waste, and (iv) creating a strategy for territorial adaptation to climate change. The adaptation category contains tree-planting programmes and projects to create new green areas (including public areas, green roofs, green facades and green walls). A sum of EUR 60 million was allocated to adaptation projects.

The preparation for the Paris climate bond was carried out by the city's Finance and Procurement Department and its Parks and Environment Department. Assistance for the preparation came from a non-financial ratings agency and three banks (whose sectoral expertise ensured that the green bond would be attractive for investors). To have its performance on sustainable development evaluated by an independent body, the city of Paris requested an 'extra-financial' rating. The climate bond is compliant with the International Capital Market Association's green bond principles, and transparency is ensured by yearly reporting (ensuring the money is used for projects that meet the set criteria). The city of Paris is responsible for interest payments of 1.75 % per year and full repayment at the end of the bond term.

The legal basis for the bond comes from the Paris climate and energy action plan (2012) and the Paris adaptation strategy (2015). The goal of the adaptation strategy is to prepare the city for future climate change and resource scarcity by meeting four objectives: (i) to protect Parisians from extreme climate events; (ii) to ensure the supply of water, food and energy; (iii) to live with climate change through more sustainable city planning; and (iv) to foster new lifestyles and boost solidarity.

The projects to be funded by the bond are selected in a two-stage process. In the first stage, municipal criteria are applied to ensure that projects contribute to (one of) the four goals of the climate and energy action plan. Only projects that have not already been initiated can be financed. In the second stage, projects are checked for compliance with the green bond principles. The second phase also includes an environment, social and governance evaluation. Meetings with project managers are held in the second phase to get more detailed information on each project (this detailed information includes concrete actions proposed, a more refined assessment of costs, and arrangements for project planning and monitoring). The projects being considered must fit into one of the eligible categories, and they must meet environment, social and governance criteria. The projects must also comply with rules on liquidity and project management. Each project must have measurable environmental benefits, with measuring procedures and instruments that can be carried out by various city departments or by a body accredited for carbon evaluation. The selection process is managed by the city's Finance Management Support Service in full collaboration with the Urban Ecology Agency of Paris. The selection process is also overseen by the non-financial ratings agency. The list of projects to choose from is drawn up at the start of each election term based on the new mayor's investment programme and must be approved by the Council of Paris.

With the increasing occurrence of heatwaves, heat stress is an important focus for Paris, and various measures are being implemented to reduce the effects of the urban 'heat island' effect. Two projects funded by the climate bond seek to improve the local microclimate and increase thermal comfort within the city: a tree-planting project, and a project to create green areas. These projects are aligned to objectives (i) and (iii) of the city's adaptation strategy. One of the targets of the adaptation strategy is to provide every Paris resident with a place to relax featuring water and greenery within 7 minutes' walking distance from their place of residence by 2020.

Indicators that measure the results of the adaptation projects are expressed as (i) the total new surface of green spaces opened to the public in square metres, (ii) the total surface of new green areas on buildings in square metres, and (iii) the total number of planted trees within the Parisian 'intra muros' area (i.e. the 20 arrondissements of central Paris).

Currently, the projects under implementation seek to plant 20 000 trees in the city and create 30 hectares of new greenery by 2020. Working groups were set up within the city administration to implement the projects, overseen by the city's green service. These groups have been divided into four units to ensure the greenery is spread evenly across the Paris area. Public meetings were held and an interactive application was launched to include residents in the design process and in project suggestions. The creation of green spaces is in line with the city's biodiversity plan, which seeks to improve ecological continuity and support biodiversity in densely built urban environments. The design of new green spaces integrates concerns about the environment and sustainability, and 78 % of municipal gardens have now received the Ecojardin label (a national label in operation since 2013, which attests to good ecological management).

Of the total tree-planting cost of EUR 18 million, EUR 15 million will be financed by the bond and EUR 3 million by the city's greening budget. The remaining EUR 45 million of the climate bond earmarked for adaptation funding will be used for creating new parks, with a total cost EUR 67 million, co-financed by the city's greening budget. By 2016, EUR 6.3 million had been spent, 3.4 hectares of green spaces had been created, and close to 2 200 trees planted. It is estimated that these trees will sequester 1 600 tonnes of CO_2 during their lifetime. Maintenance of the parks and trees will be covered by the city's general budget, since the rules of the climate bond do not allow funding to be used for operational costs. As the adaptation projects do not bring direct financial benefits, the interest on the portion of the bond that funds these projects (and the final repayment of these funds) will be paid from the general city budget. However, the city of Paris expects to generate extra revenue through its mitigation projects and through reduced energy consumption.

Creating a green bond is a long process that requires time; human resources; procedures and tools to ensure transparency; and expert advice to prove environmental or climate benefits. Independent advisers, sectoral experts in green bonds and bankers proved essential in attracting investors. In Paris, success was enabled by a clear financial framework; well-structured use of proceeds; and frequent reporting and collaboration among internal and external participants with clear responsibilities. This was all coordinated by the financial office. Finally, success was made possible thanks to the extra-financial rating that Paris was given by the rating, agency.

A new sustainability bond is planned for 2019 and a resilience bond is planned for 2020 by the city of Paris.

More information:

City of Paris — Climate bond investor presentation (2015)

https://api-site.paris.fr/images/75091

Summary of Annual Report 2016

https://api-site-cdn.paris.fr/images/94437

European Climate Adaptation Platform

https://climate-adapt.eea.europa.eu/metadata/case-studies/climate-bond-financing-adaptation-actions-in-paris

C.14. ECOSYSTEM-SERVICE ASSESSMENT TO SUPPORT BIODIVERSITY CONSERVATION IN THE OGLIO SUD PROTECTED AREA IN LOMBARDY, ITALY

Ecosystem-service assessment can support the implementation of biodiversity conservation objectives. In the Oglio Sud protected area in Italy's Lombardy region, mapping and assessing ecosystem services is used to develop payment mechanisms for ecosystem services. This case study is relevant to: integrating ecosystem services into the management of protected areas (Chapters 3 and 4), ecosystem-service assessment and ecosystem-service valuation (Chapter 3), and participatory financing.

The biodiversity-protection strategy for Lombardy, one of the biggest regions in northern Italy, places great importance on the creation of protected areas and the adoption of specific measures to protect species and habitats. It makes specific reference to the Natura 2000 network of protected areas established by the Habitats Directive. Lombardy has implemented the objectives of the Habitats Directive by creating the Rete Ecologica Nazionale (Regional Ecological Network, RER), which provides a structural and functional framework for nature conservation objectives. The Oglio Sud Regional Park is part of the RER and lies within an area that includes the Oglio river that runs downstream of Lake Iseo to the mouth of the River Po.

'Ecopay — connect Oglio Sud' is a project that aims to strengthen the ecological corridor represented by the Oglio Sud Park to enhance biodiversity protection on a local and sub-regional scale. It plans to use innovative environmental governance tools for the design and participatory financing of the preservation work. The project is co-funded by the Cariplo Foundation and the Consorzio Forestale Padano (Padano Forestry Consortium).

The importance of the Oglio River as an ecological corridor has been recognised by the establishment of many protected areas and Natura 2000 sites in the area. There are two particularly large regional parks in the area: the Oglio Nord Park and the Oglio Sud Park, both of which were created to protect biodiversity and the Oglio river. The Ecopay project is part of a wider project on biodiversity protection, which aims to improve the infrastructure of the RER and of Italy's Natura 2000 network. The actions taken as part of the Ecopay project will be coordinated and implemented by the Oglio Sud Park in collaboration with the project partners: Università degli Studi dell'Insubria (Department of Theoretical and Applied Science — DISTA), Università degli Studi di Padova (Department of Land, Environment, Agriculture and Forestry), and GAL Oglio Po terre d'acqua (Oglio Po wetlands local action group).

The project's specific objectives are: (i) to promote diversification of the riverbed and of the oxbow lake, (ii) to defragment the riparian habitat and to increase areas of vegetation, (iii) to improve water quality, (iv) to plan wildlife conservation measures, (v) to share design choices and coordinate them at the local level and between institutions, (vi) to identify legal and administrative systems for payment mechanisms for ecosystem services, and (vii) to conduct outreach activities.

The project has outlined a variety of actions to achieve these objectives. These actions are: (i) the collection and processing of updated environmental and territorial data, (ii) the detection and characterisation of the ecological corridor's critical issues, (iii) the design of actions to redevelop the riverside and oxbow lake, (iv) the design of forestation and defragmentation in the riparian habitat, (v) the design of interventions aimed at reducing the pollutant load caused by discharges to the aquatic environment, (vi) the design of wildlife conservation projects, (vii) the analysis and economic evaluation of the park's ecosystem services and of the impacts of intervention, (viii) the participatory planning of innovative tools for financing river restoration and ecological connectivity, (ix) disclosure, and (x) coordination and management.

Ecosystem service assessment and valuation: The economic evaluation of the park's ecosystem services and of the impacts of the project interventions consisted of five main stages. The first was to collect publications on the ecosystem service assessments carried out in Lombardy and in similar environments, in particular for damp or fluvial environments. The documents gathered were critically screened to create a database that would be useable for the next benefit transfer stage. In the second stage, analysis and mapping of the ecosystem services of the Oglio Sud Park was carried out using specific software and applications, such as InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) and ARIES (Artificial Intelligence for Ecosystem Services). These tools allowed the flows of ecosystem services, stakeholders and socioeconomic benefits to be quantified, mapped and analysed. In the third stage, an economic evaluation of the ecosystem services in the project area was completed. The evaluation considered two points of view: (i) the production costs and the supply methods for the potential producers, and (ii) the willingness of potential users of the service to pay. Both direct surveys and benefit-transfer techniques were used. In the fourth stage, a critical summary was made of the information gathered. This contributed to an overall assessment based on the results of the investigation. In the fifth and final stage, the collected data and results were used as a starting point for designing payment mechanisms for ecosystem services.

Ecosystem-service scenarios: The analysis evaluated in economic terms the ecological functionality of the Oglio Sud Regional Park. It assigned monetary values to the benefits that the park is able to generate for the well-being of the population. The ecosystem services represent a considerable component of the park's natural capital, and have allowed a preliminary estimate of the park's economic value to be generated. To provide technical suggestions and investment strategies that would integrate the need for economic development and ecosystem conservation, three potential areas of action have been evaluated. These potential areas of action could help address the environmental problems that limit the balance and functionality of the park's ecosystems. These areas of action are based on specific needs, such as:

- *the defragmentation of the ecological corridor and suburban habitats (Scenario 1: Reforestation of the riparian areas);*
- *opportunities offered by the conditionalities imposed by the common agricultural policy (Scenario 2: Plantations); or*
- *the economic utilities that could be created by environmental and landscape redevelopment interventions (Scenario 3: Network of tree rows).*

The project has been successful at highlighting the importance of investing in the area. From the feedback received and the concrete results that the working group has been able to achieve, there is a desire to apply the same model to other areas, and partners will engage on this subject in the coming years. The project has succeeded in promoting a second phase of the programme, called 'Ecopay Connect 2020'. This project involves four important protected areas at the regional level (Parchi del Mincio, Oglio Nord, Oglio Sud, and Alto Garda Bresciano), with the aim of enhancing ecological connectivity and functionality in eastern Lombardy.

More information:

https://www.dropbox.com/sh/1horsd1svv9mnp7/AABQaWu1pA4mCkP49r3_Iz5da?dl=0&preview=_Descrizione+del+progetto.pdf

http://www.ogliosud.it/pagina.php?id=108

http://www.etifor.com/it/portfolio/ecopay-connect-2020/

C.15. STRATEGIC ENVIRONMENTAL ASSESSMENT TO INTEGRATE ECOSYSTEM SERVICES INTO COASTAL ZONE MANAGEMENT, PORTUGAL

Integrated coastal zone management (ICZM) strategies supported by SEAs help integrate ecosystem services into coastal planning. The Portuguese national ICZM strategy used the SEA process to incorporate ecosystem-service information into the design and implementation of the ICZM. This case study is relevant to: marine spatial planning (Chapter 4) and strategic environmental assessments (Chapter 3).

The Portuguese national strategy for ICZM, was completed in 2009. It aims to ensure sustainable development of the coastal zone, and address conflicts between (i) sectors that operate in the zone and (ii) uses that rely on different ecosystem services. The primary policy driver for the development of the strategy was the EU Marine Strategy Framework Directive.

The national strategy had several specific objectives, including to: (i) conserve resources, natural heritage, cultural heritage and landscape heritage; (ii) rehabilitate coastal zones and ensure the sustainable development of activities and uses; (iii) mitigate risks, social impacts, economic impacts and environmental impacts; (iv) improve scientific knowledge of coastal ecosystems; and (v) ensure public participation and raise social awareness.

Role of science-policy studies: The preparatory studies for the national strategy identified several risks for the coastal zone. These risks included (i) the stabilisation of dynamic ecosystems by human land uses, (ii) increased risk of natural hazards induced by climate change, and (iii) coastal erosion. These studies also highlighted the increased risks caused by the current state of coastal defences, including the lack of maintenance, the false sense of security they create, and their intrusive nature. The studies said that the protection and restoration of coastal zones should be prioritised to mitigate such risks. The studies also discussed natural and cultural heritage, biodiversity, and the sustainable use of resources. To assess these vulnerabilities, risk maps were produced, but it has been suggested that the vulnerabilities could be better assessed by incorporating a wider range of scenarios and including more field data.

Role of strategic environmental assessment (SEA): No dedicated ecosystem-services mapping and assessment was carried out. However, an SEA was carried out to inform the development of the final strategy. The SEA compared policy options for governance, institutions, and the thematic focus of the strategy. It made this comparison on the basis of the potential benefits and risks of the options (including the benefits and risks to the provision of ecosystem services). The options considered for the thematic focus were (i) naturalisation of the coastal zone, (ii) use of the ecosystem approach to jointly address ecological and socioeconomic dynamics, and (iii) 'artificialisation' of the coastal zone based on replacing or compensating for natural hydrodynamic processes. The institutional options considered were fragmented, joint, or centralised responsibilities for coastal zone management. The governance options were strengthened public and state policies, public-private cooperation, and investment (which would be mostly private).

The use of an SEA to inform the national strategy was not legally mandated. However, the SEA was used voluntarily to ensure that the management strategy effectively integrated environmental issues and accounted for environmental and sustainability-related risks and benefits. In particular, the SEA aimed to ensure the use of the ecosystem approach in the national strategy, so that the risks and benefits of the strategy for ecosystem services were considered.

The SEA process involved assessing policy options for the national strategy in terms of how they could benefit or present risks for ecosystem services. The SEA decided on several critical factors for decision-making, which were chosen to ensure that the design, implementation and monitoring of the national strategy were sustainable. In deciding on these critical factors, good practices for coastal management were taken into account, including those established in the Recommendation of the European Parliament and of the Council concerning the implementation of ICZM (2002/413/CE). In this way, the critical factors reflected strategic priorities for the coastal zone and factors for successful implementation of the strategy.

Guiding principles for decision-making, planning and targeting: Four critical factors were ultimately decided on to guide the structure of the SEA. These four critical factors were: (i) ecological systems and coastal landscapes, (ii) coastal resources and uses, (iii) natural and technological risks, and (iv) management and governance. The selected critical factors reflected the strategic drivers of the national strategy, the current policy framework for coastal zone management, and the need for environmental protection and sustainability. For each critical factor, a set of assessment criteria were drawn up. The criteria for the first critical factor on ecological systems and coastal landscapes were (i) to use the ecosystem approach in the management of the coastal zone, and (ii) to preserve natural and cultural heritage.

The critical factors were then used in two ways for the design and implementation of the strategy. They were first used in (i) identifying strategic options, in terms of the themes, institutions and governance of the strategy, and (ii) for informing the actions and measures included in the strategy. As part of this discussion, the valuation of socio-ecological systems was identified as a priority strategic option. The second way that the critical factors were used was for the creation of guidelines. A set of guidelines for implementation of the strategy was developed for each critical factor. The guidelines were organised into three categories: (i) planning and management (to guide planning decisions following approval of the strategy and in the development of models for coastal zone management), (ii) monitoring of the strategy and its implementation, and (iii) governance of the strategy to ensure its successful implementation in terms of the risks and benefits identified in the SEA. Therefore, under the 'ecological systems and coastal landscapes' critical factor, the design and implementation of the national strategy incorporated (i) the use of the ecosystem approach and (ii) the protecting and valuing of natural heritage and biodiversity.

Scientific information was used as the basis for the SEA and national strategy, and authorities and NGOs contributed to the identification of the critical factors for decision making. A key recommendation of the SEA was that both the SEA and national strategy should be opened to discussion among a wider range of stakeholders.

One of the key lessons from the SEA of the national strategy is that the strategy is well-developed for addressing the prevention and management of natural and climate change-related risks through an adaptive institutional framework that takes into account ecosystem services. However, the strategy could benefit from greater adaptation to local conditions and the incorporation of traditional ecological knowledge.

More information:

Partidário, M.R., 2011. TEEB Case: Including ecosystem services in coastal management by using Strategic Environmental Assessment, Portugal. Available at www.teebweb.org

Partidário, M.R., Vicente, G. and Lobos, V., 2009. Strategic Environmental Assessment of the National Strategy for Integrated Coastal Zone Management in Portugal. Journal of Coastal Research, SI 56 (Proceedings of the 10th International Coastal Symposium), 1271 – 1275.

Veloso Gomes, F., 2007. A gestão de zona costeira Portuguesa. Revista da Gestão Costeira Integrada, 7(2): 83-95.

D. EXAMPLES OF SOCIOECONOMIC VALUE OF ECOSYSTEMS AND THEIR SERVICES

There is a vast and compelling body of evidence on the wide range of — and major socioeconomic benefits from — ecosystems and their services in different contexts. The table below provides a few examples of estimated values of ecosystem services in different contexts. These examples are taken out of TEEB country studies which in turn draw on further background sources.

It is important to note that these examples of monetary values cannot be applied across the board because they depend on many parameters - in the context in which the valuation was made (e.g. farming systems, wider socioeconomic factors, perceptions, availability of alternatives etc.), in the availability and choice of data taken into account, in the valuation methods used etc. They serve to illustrate the benefits of ecosystems and their services but remain specific to the contexts in which the valuation was made.

The documents from which the examples below stem provide further detail on the methodologies used, the limitations or uncertainties involved, and the application of the values derived.

Natural Capital Germany — TEEB DE, 2016. Ecosystem services in rural areas — Basis for human well-being and sustainable economic development. Summary for decision-makers. Leibniz University Hanover, Helmholtz Centre for Environmental Research — UFZ, Leipzig.	
Grassland ecosystem services	Grassland supports the supply of many ecosystem services, such as climate protection, water protection, and protection from erosion. High nature-value (HNV) grassland is also vital for conserving biodiversity. Ploughing up grassland therefore entails significant costs for society, estimated at between EUR 440 and EUR 3 000 per hectare per year. From a societal perspective, it is essential and economically advantageous to conserve grasslands, especially HNV grassland.
Nitrogen regulation on **agricultural land**	Excessive nitrogen emissions impair human health and damage the environment. More than 50 % of reactive nitrogen compounds in Germany enter the environment as a result of intensive agriculture. Optimised land use in drinking-water catchment areas ensures that nutrient emissions are avoided at the source. This is many times more cost-effective than treating water after it has been polluted. The Leipzig water utility estimates that cooperation in the catchment areas of its wells may cost as little as 15% of the alternative of technically treating heavily polluted groundwater. Ecological land-use practices provide additional benefits by conserving biodiversity, surface waters, rivers and the sea. These practices also help to protect the climate. A study by TU Berlin

	found that current nature conservation measures to minimise the impacts of nutrients in floodplains, peatlands and agricultural landscapes save around EUR 230 million each year. The study also estimates that additional nature conservation measures based on the German national biodiversity strategy would save a further EUR 150 million per year simply by reducing nutrient pollution.
Structural elements on **agricultural land**	Structural elements (such as hedges and extensively used or unused field margins and riverbank buffer zones) are valuable elements of the cultural landscape. These elements support species conservation and provide a wide range of ecosystem services that benefit both farmers and society. Leaving even a small area of land unused can produce enormous benefits: wind protection hedges can boost yields by up to 50 % in the lee of the hedge (the lee of a hedge can extend out to a distance equivalent to 15-to-25 times the height of the hedge). Small structures and soil-friendly, sustainable agricultural practices can help to reverse soil erosion. A study in Lower Saxony revealed that the economic benefits of riverbank buffer zones for protecting surface waters, marine ecosystems and biodiversity are at least 1.8 times their investment costs.
Benefits from **tourism** in national parks	National natural landscapes (national parks, biosphere reserves, nature parks) provide ecosystem services such as climate regulation and groundwater protection. At the same time, their great importance for recreation and tourism helps to create social and economic value. For example, tourism in the Bavarian Forest National Park generates an estimated real net output of EUR 13.5 million per year for the region, more than the revenues lost as a result of restricting forestry use. Germany's 16 national parks only cover 0.6 % of the national territory, but more than 50 million people visit these parks each year. Some 85 000 jobs in the tourism sector depend on Germany's national parks alone (figures exclude Black Forest and Huensruck-Hochwald).
Climate costs **of peatland degradation**	Intact, peat-accumulating peatlands in Germany have been reduced to 1 % of their original size. Drained peat soils only account for around 6 % of agricultural land, but drained peat-soil degradation is responsible for 54 % of CO_2 emissions from agricultural soils, and 37 % of total CO_2 emissions from farming. In Mecklenburg-West Pomerania, degraded peat soils account for more GHG emissions than transport and industrial activity put together.
Societal costs from ploughing up HNV grassland	Many grassland areas are capable of generating higher operating revenues for land owners/managers if they are ploughed-up to grow other agricultural crops, such as corn for animal feed or energy cropping. The German Federal Agency for Nature Conservation estimates that arable use can increase revenues from grasslands by EUR 435/ha/year. Some examples of societal costs from ploughing up grassland and converting it to arable land (e.g. corn fields) from the German TEEB are listed below. - Global damage from additional CO_2 emissions of 8.8-18.7 t CO_2/ha/year over 10 years, valued at between EUR 700/ha/year

	and EUR 2 240/ha/year. - Higher nutrient emissions contaminating groundwater and surface waters,were estimated at EUR 20-40 to 120 EUR/ha/year depending on the type of farming practices. - Biodiversity loss: a representative survey (2012) found that the German public is willing to pay between EUR 1.35 billion and EUR 5 billion per year to protect, plant and upgrade 4.8 million ha of grassland to preserve biodiversity. This equals an average willingness to pay of EUR 300-1000/ha/year.
Forest ecosystem services	TEEB draws on German nationwide studies which have estimated the value of the benefits of forest recreational services and biodiversity conservation at around EUR 2 billion per year. The study notes that this estimated value is on a par with the production value of raw wood. This needs to be considered while keeping in mind that estimates of intrinsic and recreational values are strongly influenced by the methodology used, cultural and socio-economic factors. Furthermore, the benefits may flow to different users. Forests and forest management also play a key role in the achievement of climate targets. They also have a balancing and stabilising effect on the hydrological regime. Structural diversity encourages this effect. The TEEB study refers to findings that groundwater reserves underneath forests are better protected from nitrate emissions, with deciduous forests the most effective at buffering atmospheric nitrogen emissions. Groundwater recharge also tends to be higher under deciduous than coniferous forests.
TEEB Slovakia. Bujnovsky, R: Evaluation of ecosystem services of inland waters in the Slovak Republic — to date findings. Ekologia (Bratislava), Vol. 34, No 1, p. 19-25, 2015	
Ecosystem services of freshwater ecosystems in the Slovak Republic	In a 2015 evaluation of freshwater ecosystem services in Slovakia, the value of services related to the provisioning of irrigation water was estimated at EUR 25.7 million for the period 2011-2013. The value of recreational fishing was estimated at EUR 7.91 million for 2012, and the value of services for swimming and recreation was estimated at EUR 1.15 million for the period 2011-2013.
TEEB for Nordic countries. Kettunen, M., Vihervaara, P., Kinnunen, S., D'Amato, D., Badura, T., Argimon, M. and ten Brink, P. (2013) Socioeconomic importance of ecosystem services in the Nordic countries — Synthesis in the context of the Economics of Ecosystems and Biodiversity (TEEB), Summary for policy makers, Nordic Council of Ministers, Copenhagen	
Fisheries provisioning in the Nordic countries	The fisheries industry is of great national and regional importance in the Nordic countries. The economic value of fish catches ranges from over EUR 25 million per year in Finland to over EUR 2 billion per year in Norway. There are over 6 million recreational fishermen in the Nordic countries. In Sweden, the net value of recreational fishing has been estimated at almost

	EUR 79.5 million, exceeding the value of commercial fishing.
Forest non-timber provisioning (berries)	The estimated economic value of forest berries picked for markets was estimated at over EUR 30 million per year in Sweden in 2005. In addition to berries traded on organised markets, a significant amount of berries are also consumed directly by those who gather them. For example, in 2000 the value of berries sold in market places and directly to households or restaurants in Finland was estimated at EUR 3.9 million, while the value of berries collected for household use was evaluated at EUR 53.8 million.
Forest non-timber provisioning (hunting)	The socioeconomic importance of hunting in the Nordic countries is a combination of revenue-providing activity, household subsistence value, and cultural and recreational significance. Around one million Nordic people go hunting every year — almost 5 % of the total Nordic population. Estimates for the value of game meat obtained from Finland, Sweden and Norway range between EUR 44 million and EUR 125 million.
Forest nature-based recreation	Recreational activities in nature are extremely popular in Nordic countries. An average adult Finn engages in an outdoor activity three times a week. In Sweden, 36-56 % of people reportedly use forests for walking at least 20 times a year. In Norway, almost half of the population (i.e. around 2.4 million people) hike in forests or mountains more than twice a month. Approximately 70 % of Danes visit green areas several times a week. In Sweden, the value added from expenditure on outdoor activities was calculated at approximately EUR 4 million, and spending on outdoor activities was estimated to support over 75 000 jobs. In Finland, financial support for the management of national parks and their recreation opportunities has been estimated to provide up to EUR 10 in regional-investment return for every EUR 1 invested.
Forest carbon sequestration	In Finland, the value of carbon sequestration of forest trees is estimated at EUR 1.876 billion, and the value of change in mineral soil carbon stock is estimated at EUR 136 million. The annual carbon sequestering value of Swedish forests is estimated at between EUR 3.3 billion and EUR 5.2 billion.
Insect pollination	In Finland, the value of pollination by honeybees has been estimated at around EUR 18 million for selected crops and EUR 39 million in home gardens. In Denmark, the annual value of general insect pollination was calculated to be worth between EUR 56.6 million and EUR 92.8 million. In Sweden, the value of honeybee pollination was calculated at between EUR 21.5 million and EUR 37 million.
Genetic resources	There is increasing interest in biotechnological applications based on Nordic and Arctic genetic resources. A number of Nordic plant compounds are used by the pharmaceutical industry. Altogether, 134 wild Nordic plant species have been identified that have medicinal or aromatic properties and that are of current socioeconomic interest. Recent examples of scientific screening of Nordic plants include sage species tested for their effect on type-2-diabetes in Denmark and Corydalis species to treat Alzheimer's

	disease.
TEEB for Czechia. Hönigová, I. et al. Survey on grassland ecosystem services. Report to the EEA — European Topic Centre on Biological Diversity. Prague: Nature Conservation Agency of the Czech Republic, 2012. page 78.	
Livestock provision services of **grassland**	Pastures and managed grasslands in the Czech Republic provide the largest capacity for livestock provision, estimated at a total value of EUR 507 million per year. On a per hectare basis, the largest values are found in alluvial, wet and mesic meadows. This is due to their higher average levels of net primary productivity, which is a prerequisite for grazing (semi-natural grasslands can support 1.3–1.6 livestock units per hectare of grassland habitat, while pastures and meadows support on average 0.75 livestock units per hectare of land).
Carbon sequestration in **grassland**	The total area of Czech grasslands sequester 550 Mg of carbon annually, with a value of EUR 47 million per year. Semi-natural grasslands sequester 36 % of this carbon, while pastures and managed grasslands sequester the other 64 %. Intensities of carbon sequestration differ among habitat types, with maximum values reached in alluvial and wet meadows. Carbon sequestration is also dependent on the disturbance regime, biodiversity, and net primary productivity. Conversion of grassland to cropland can release up to 0.90 Mg of carbon per hectare per year on average over a 20-year period (with large variability of the estimates in literature depending on local conditions, arable farming system, assessment methodology and other factors). Conversion of arable land to permanent grassland was generally estimated to result in storage of 0.49 Mg of carbon per hectare per year over 20 years (again, with wide variations). The Czech survey of grassland ecosystem services suggests a marginal abatement cost of EUR 84 t CO_2.
Erosion abatement by **grassland**	Grasslands in the area of assessment showed reduced soil-erosion rates, by 2.2–2.5 Mg per hectare per year more than arable land. In total, there was 2.1 million Mg less soil erosion from grasslands than from cropland. The annual benefits of grass cover in reducing erosion were estimated at EUR 265 per hectare of land in 2010. The value of soil-erosion regulation services is estimated at EUR 258 million annually.
Regulation of water quantity and quality (N-removal) in **grassland**	Grasslands were also found by this study to take up a considerable fraction of rainwater and help regulate floods and droughts. The value of grassland water-regulation services was estimated at EUR 1.6 billion. Water regulation was thus the ecosystem service with the highest value, due to the relatively high costs of artificial water-retention alternatives. Grasslands also regulate water quality due to their dense root systems and ability to filter nutrients. The value of nitrogen removal by grasslands (expressed as the operational clean-up cost for the same amount of nitrogen in a conventional wastewater treatment

	plant with biological elimination of nitrogen) was estimated at EUR 161.9 per hectare in 2010 prices. In the Morava river floodplain, nitrogen abatement makes up a significant part of the total economic value of grasslands.
Recreation by **grassland**	The recreation value of grasslands for the entire Czech population (7.9 million people) was estimated at EUR 54.10 per hectare per year.
Invasion regulation by **grassland**	Semi-natural grasslands with conserved numbers of native species can serve as a barrier to invasion. Semi-natural grasslands (dry, wet and saline) or forest fringes have low levels of invasion despite relatively high invasion pressure. The total value of invasion regulation by grasslands in Czechia, based on available data, was estimated at EUR 7.1 million.
Relative socioeconomic value of different **grassland** habitats	The highest value of ecosystem services is reached in seasonally wet and wet grasslands, followed by alluvial meadows. Both provide service values of more than EUR 4 000 per hectare. These are followed by mesic grasslands, forest fringe vegetation, alpine and subalpine grasslands, and dry grasslands (comparable benefits in the range of EUR 2 585 - EUR 3 119 per hectare of habitat). Pastures, managed meadows and heathland provide relatively low economic values. The dominant component of ecosystem services is water flow regulation, followed by livestock provision and erosion regulation.