

**APPENDIX 1 – SUPPLEMENTARY DATA: TOOLS FOR MODELLING ECOSYSTEM SERVICES TRADE-OFFS AND SCENARIO ANALYSIS ORGANIZED FROM THE MOST CITED TO THE LEAST CITED.**

Abbreviation	Name	Input	Output	Scale	Cost	Software	Skills	ES	Specific ES	Datasets	Time	Reference
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs	Predominantly GIS / map data; information tables (usually.csv format)	Maps	Site, Local, Landscape, Regional, National, Multi-scale	Open access (free)	ArcGIS ArcToolBox , QGIS	Basic – intermediate GIS skills	Regulating Provisioning Cultural	Carbon Storage and Sequestration , Coastal Blue Carbon , Coastal Vulnerability, Crop Pollination, Fisheries Production, Habitat Quality, Habitat Risk Assessment, Marine Fish Aquaculture, Nearshore Waves and Erosion, Offshore wind energy, Recreation , Reservoir Hydropower Production, Scenic Quality, Sediment Retention, Water Purification, Wave energy	Land-use/ land-cover map; Carbon stock values (carbon stored above and belowground biomass, dead organic matter and soil); Features impacting scenic quality (point data); Digital Elevation Model; Refractivity coefficient; Population data; Rainfall Erosivity Index; Soil erodibility; Watersheds; Biophysical table; Threshold flow accumulation; Hydrology and soil texture calibration parameters (defaults available); Root restricting layer depth; Precipitation values; Plant available water content; Average annual potential evapotranspiration rates; Water purification valuation table; Water purification threshold table.	Moderate-high. Simple analysis - 1 day. Detailed stakeholders’ engagement project - several years.	1, 2,3, 4 ,6, 7, 8,9,10,21
ARIES	ARtificial Intelligence for Ecosystem Services	Spreadsheets, databases (e.g. Access), maps (global maps are available by default online) or GIS databases	Maps, Quantitative data on ecosystem services and environmental asset portfolio	Local, Landscape, Regional, National, Multi-scale	Open access (free)	Standalone k.Lab software tool environment. ARIES Explorer (k.Explorer)	Technical / GIS / modelling skills (training advised)	Regulating Provisioning Cultural	Carbon sequestration and storage, Riverine flood regulation, Coastal flood regulation, Nutrient regulation, Sediment regulation, Water supply, Fisheries, Pollination, Aesthetic value, Open space proximity, Recreation	Most ARIES flow models use the spatial distributions of the sources of service-carrying medium, beneficiary demand, and potential sinks, specified as maps covering the area under study.	High ~130 days	1, 2, 7 , 8, 9, 21
SWAT	Soil and Water Assessment Tool	Maps / GIS	Maps	Watershed	Open access (free)	ArcSWAT a plugin for ESRI ArcGIS	Training effort high	Provisioning Regulating	Freshwater production, water purification and sediment regulation.	Soil hydrological group, Maximum rooting depth of the soil profile, Depth from the soil surface to the bottom of the layer, Moist bulk density, Available water capacity of the soil layer, Saturated hydraulic conductivity, Organic carbon content, erodibility K factor, Moist soil albedo; Clay, silt, sand and rock fragment content	High	1, 7, 12
LUCI	Land Utilisation and Capability Indicator	Maps / GIS data available at a national scale	Maps; Quantitative data on ecosystem services; Tables / statistics / reports	Site, Local, Landscape, Regional, National, Multi-scale	Prototype (not yet available)	ArcGIS 10.1 or above.	Basic – intermediate GIS skills	Provisioning, Regulating	Flood mitigation, Erosion risk, Sediment delivery, Water quality, Carbon sequestration, Agricultural productivity, Habitat networks, Priority habitat, Trade-off/synergy identification.	Gridded digital elevation model (DEM) ideally at 5m or 10m resolution, Land-use/ land-cover data, Soil data, Species dispersal information including cut-off 'costs' and the spatial coverage of habitats of interest for the species of interest, Hydrologically consistent DEM (generated by tool)	Moderate	1,2,4,8
RIOS	Resource Investment Optimization System model	Socio-economic data and biophysical input data	Investment Portfolio, containing raster files and tables with the results.	Watershed or landscape	Open access (free)	RIOS model	Training effort medium to high	Regulating Provisioning	Erosion control for drinking water quality or reservoir maintenance, nutrient retention, flood mitigation, groundwater recharge enhancement, dry season base flow, and biodiversity.	Average rainfall; Rainfall depth; annual actual evapotranspiration; Rainfall erosivity; Soil erodibility; Soil depth and texture; Location and number of beneficiaries	Medium	1, 12
MIMES	Multiscale Integrated Models of Ecosystem Services	Surveys, GIS, and remote sensing data	Maps; Quantitative data on ecosystem services; Tables / statistics / reports	Local, Regional, Global	Open source, but requires commercial modeling software Simile	Simile version 6.9	Experienced systems modeler	Regulating Provisioning Supporting Cultural	Eleven biomes or ecosystem types: Open Ocean, Coastal Ocean, Forests, Grasslands, Wetlands, Lakes/Rivers, Deserts, Tundra, Ice/rock, Croplands, and Urban.	Relevant spatial data	High to develop and to apply new case studies	2.8,9,20
Co\$ting Nature	Co\$ting Nature	Global spatial data (GIS, remote sensing) at 1 square km or 1 ha resolution is provided by the tool. Users can also provide their own datasets.	Maps	Local, Landscape, Regional, National, Multi-scale	Open access (free)	The internet (it works best in Chrome or Mozilla Firefox); GIS software to view or to analyse output maps (not essential).	Internet use skills	Regulating Provisioning Cultural	Water quantity, Water quality, Water provisioning, Carbon storage and sequestration, Recreation, Biodiversity, Conservation priority, Threats and pressures	Global datasets (e.g. for land-use and carbon storage) are provided with the tool as a standard. Additional local data can be provided by the user.	Low-moderate	1,2,8,9
EcoAIM	Ecological Asset Information Management	Incorporates stakeholders’ preferences via modified risk analysis approach	Spatially explicit ecosystem service tradeoff maps, graphs	Watershed or landscape	Proprietary tool	EcoAIM™, GIS-based software programmed as a ToolBox within an ArcGIS framework	Basic – intermediate GIS skills. Technical / GIS / modelling skills (training advised)	Regulating Provisioning Cultural	Vista aesthetics, Landscape aesthetics, Recreational opportunities, Habitat provisioning for supporting biodiversity, Nitrogen sequestration.	Land-use plans, mission requirements, and visions of study area future elicited from the site-specific problem formulation task.	Relatively low for basic mapping, greater for nonmonetary valuation	2.8, 13, 14, 21
EcoMetrix	EcoMetrix	The conceptual models, which are developed as part of the analysis, determine the specific data needs	Maps, Tables or scorecards, Bar graphs	Site	Proprietary tool	None - the tool is a proprietary tool provided by the developer.	None – the tool is run by a consultant	Regulating, Provisioning	Carbon, water, aesthetic, recreation, cultural heritage, biodiversity	Physical attributes of the landscape (e.g., soil, vegetative structure, water regime, etc.)	Relatively low to support field visits and data analysis	2,8,21
EcoServ-GIS	EcoServ-GIS	Freely available GIS datasets and OS MasterMap Topography data.	Maps	Regional, Landscape, Local	Open access (free)	ArcGIS Desktop (10.2.2 onwards) with the Spatial Analyst Extension (Advanced License).	Basic – intermediate GIS skills. Technical / GIS / modelling skills (training advised)	Cultural, Regulating	Air Purification, Carbon Storage, Local Climate, Noise Regulation, Pollination, Water Purification, Accessible Nature, Education Knowledge, Green Travel, Multi-functional landscapes, Multi green-infrastructure assets.	Study area boundary, MasterMap Topography layer, OS VectorMap, Urban areas and Ancient Woodland Inventory data (supplied in toolkit), • Open Space Typology, Landscape Character Area (usually not recommended), Biodiversity Action Plan Habitats (or Natural England’s Priority Habitats Inventory), Digital Elevation Model, Woodland Survey (Scotland), Land use/ landcover map, Socio-economic point data, Soil data	Moderate Min 17 days, average 33 days, max 68 days.	1,2,8, 10

Abbreviation	Name	Input	Output	Scale	Cost	Software	Skills	ES	Specific ES	Datasets	Time	Reference
ESR	Corporate Ecosystem Services Review	Spreadsheets, databases	Maps, Table, list	Multiple scales	Open access (free)	not specified	not specified	Regulating Provisioning Cultural	27 ecosystem services	Most data is qualitative and gathered through stakeholders' engagement or secondary data. Other useful data sources include censuses, historical texts, land cover maps, resource specific data, etc.	Low, depending on stakeholders' involvement in the survey process (6 to 13 weeks)	2,8,9, 15
EPM	Ecosystem Portfolio Model	GIS data and values	Map that can become a “visual index”	Watershed or landscape (place-specific)	Open access (free)	Web-accessible tool	Internet use skills	Regulating Provisioning Supporting Cultural	model the impacts of alternative land uses on economic, environmental, and quality of life	Land cover, parcel location and other relevant model-specific characteristics	High to develop new case studies, low for existing case studies	2,8, 17, 18
ESValue	ESValue	Data is collected through surveys at public meetings	Spreadsheet, report	Watershed or landscape	Proprietary tool	Spreadsheet-based	Personal training or support may be available for a price.	Regulating Provisioning Supporting Cultural	Multicriteria analysis of 22 ecosystem services	Not specified	200 hours to apply and to analyze	2,8,9,21
ESTIMAP	Ecosystem Service Mapping Tool	GIS data and values	Maps, Statistic	Global	Open access (free)	The models can be computed using any type of GIS software, licensed (ArcGIS) or open source (GRASS, QGIS, R, etc)	GIS expertise is required to manipulate the models	Regulating Provisioning Cultural	Outdoor recreation, Crop pollination, Coastal protection and Air quality regulation.	Land use Forest management data/quiet areas, Sports facilities/camping/paths/skiing tracks, Sea/fresh water, Public parks, urban trees / infrastructures, Naturalness of habitats, Number of layers, Protected areas/protected trees/geological heritage, Fresh water/sea beaches, Green and cultural infrastructure, cultural elements and architecture, parks, gardens, Infrastructure supporting recreational services – viewpoints, trails, signs, info panels.	Time and economic resources strictly depend on the expertise of the researchers and GIS specialists	22, 23, 24
Solves	Social Values for Ecosystem Services	Maps / GIS (spatial and non-spatial responses to public value surveys).	Maps	Landscape or watershed	Open access (free)	toolbox for ArcGIS	Technical / GIS / modelling skills	Cultural	Aesthetic appreciation, recreation, spiritual experience and identity, tourism.	SolVES requires environmental data in raster form. Community responses to survey data must be collected and associated with raster environmental data.	Fast to use once data is collected	1,2,9, 21
Envision	Envision	GIS data and values	Maps and associated information containing spatially explicit depictions of landscape attributes and patterns	Landscape (place-specific)	Open access (free)	Envision Software (easily-used "plug-ins")	Basic – intermediate GIS skills	Regulating Provisioning Supporting Cultural	Tourism, Recreation, Cultural heritage, Groundwater provision, water quality and pollution, Climate change	Not specified	High to develop new case studies	2,8,9
TESSA	Toolkit for Ecosystem Service Site-based Assessment	Data gathered by the user for the site being assessed.	Guidance; Quantitative data on ecosystem services; Tables / statistics / reports	Site, Local	Open access (free)	Adobe acrobat to read the interactive pdf, plus 184 MB storage space.	Internet use skills	Regulating Provisioning Supporting Cultural	Cultivated goods; harvested wild goods; water provision; global climate regulation; flood protection; coastal protection; water quality improvement; pollination; nature-based recreation; cultural services.	Habitat map of the site under current and alternative conditions; Other data requirements depend on the services being assessed and the methods being applied	Moderate (20-60 days in the UK )	1,8,9
NAIS	Natural Assets Information System	Land or aquatic cover type layer and the polygon layer that summarizes the ecosystem service values.	Maps	Watershed or landscape	Proprietary tool	GIS mapping	None – tool is run in-house by a consultant	Not mentioned	Not mentioned	Proprietary valuation database paired with GIS mapping of land-cover types for point transfer	Variable depending on stakeholders' involvement	2,8,21
Benefit	Benefit Transfer and Use Estimating Model Toolkit	Spreadsheet tables	Guidance; Quantitative data on ecosystem services; Tables / statistics / reports; Economic assessment	National (place-specific - only USA)	Open access (free)	Publicly available spreadsheets	Excel skills	Regulating, Recreation	Fishing; General Recreation; Hunting; Wildlife Viewing	Average values for species, habitat types, and recreation activities along with databases of individual study values.	Low	2,8
ESII	Ecosystem Services Identification and Inventory	Ecological information collected at the site	Two metrics: a common metric of percent performance and a service-specific metric of absolute performance in biophysical units	Multiple scales	There is no cost for version one. Prototype	iOS-based Field App. Web-based project workspace and an iPad app for data collection in the field	Internet use skills	Regulating Provisioning Cultural	Aesthetics—noise and visual; Air Quality—Nitrogen and Particulates; climate regulations; carbon uptake; erosion control; Mass wasting; flood mitigation; Water quality—Nitrogen and Sediment; Water Provisioning; Water quality control; Other ecosystem services will be added in the future.	Site specific data is collected in the field through photos and a questionnaire.	Not specified	9, 16
EVT	Ecosystem Valuation Toolkit	GIS data and values	Quantitative, reports range of values	Federal, provincial, territorial, regional, watershed or municipal scale	Proprietary tool	Web-based, comprehensive collection of online tools and resources for economic valuation of natural capital	None	Regulating Provisioning Supporting Cultural	Valuations by ecosystem service, habitat type, and location.	Valuation databases that combine a library of economic valuation studies with GIS analysis of land cover, which can be used for economic valuation via point transfer	Assumed to be relatively low	2,8
EnviroAtlas	EnviroAtlas	Choosing among seven broad benefit categories	Diagram	Multiple spatial resolutions from watersheds to fine-scale community data	Open access (free)	GIS	Little technical knowledge or scientific background is necessary		Clean air, Clean, plentiful water, natural hazard mitigation, climate stabilization, recreation, culture, and aesthetics, food, fuel materials, biodiversity conservation	Data is available through the web-based tool. Data is very limited for Alaska and Hawaii.	Not specified	9, 19
i-Tree Eco	i-Tree Eco	User-collected field data	Tables / statistics / reports	Multi-scale, Regional,	Open access (free)	Microsoft Excel, ArcGIS Desktop with Spatial	Basic – intermediate GIS/Excel skills.	Cultural Regulating	Pollution removal, Air purification and quality, Carbon storage and sequestration,	The toolkit employs user-collected field data. The user can choose to adopt a 'full inventory' (whereby all trees are surveyed within a study area), or a	Not specified	1,11

Abbreviation	Name	Input	Output	Scale	Cost	Software	Skills	ES	Specific ES	Datasets	Time	Reference
				Landscape, Local		Analyst Extension (optional).			Tree disease risk, Avoided runoff, Energy effects	'sample inventory' (where a number of fixed area plots are surveyed; usually for larger-scale projects).		
InFOREST	InFOREST	GIS datasets (existing spatial data). Other data sources	Maps	Site to landscape scale, (place-specific - Virginia State)	Web-accessible tool	Online interface, Web-accessible tool	Internet use skills	Regulating Provisioning	Air quality, biodiversity, carbon sequestration, nutrient and sediment runoff, open lands	Not specified	Low, accessed through online interface	2.8
NatCap	Natural Capital Planning Tool	Data about the proposed development site such as pre- and post-development land-use information added by the user into an Excel spreadsheet.	Guidance, Ecosystem service impact score / Development impact score	Site, Local	Open access (free) Prototype (not yet available)	Microsoft Excel.	Excel skills	Regulating Provisioning Cultural	Harvested products, Aesthetic values, Recreation, Water quality regulation, Flood risk regulation, Air quality regulation, Local climate regulation, Global climate regulation, Soil contamination, Biodiversity.	Type and area of actual land use prior to development. Type and area of proposed land use after development, Population density statistics, Flood risk maps, Soil type, etc.	Low (few hours to few days)	1,12
SENCE	Spatial Evidence for Natural Capital Evaluation	GIS datasets (existing spatial data). Other data sources, such as earth observation and remotely sensed data can be used.	Maps, Tables / statistics / reports	Local, Landscape, Regional, National, Multi-scale	Proprietary tool	None - the tool is run by Environment Systems	None – tool is run in-house by a consultant	Regulating Provisioning Supporting Cultural	Natural flood management; Erosion risk management; Water quality (sediment); Climate regulation – soil carbon; Climate regulation – vegetated carbon; Climate regulation – marine carbon; Terrestrial biodiversity; Marine biodiversity; Pollination; Timber resource; Recreation, historic, landscape and open spaces; Fisheries resource; Terrestrial Food provision – Crops; Terrestrial Food provision – Livestock; Marine area that provides food;	Habitat type; Soils; Geology; Digital Terrain Model; Management information;	Days to weeks	1,10
BeST	Benefits of SuDS Tool	SuDS scheme data in an Excel spreadsheet	Guidance; Quantitative data on ecosystem services; Tables / statistics / reports; Economic assessment	Site, Local	Open access (free)	Microsoft Excel	Excel skills	Regulating Provisioning Cultural	Air Quality, Amenity, Biodiversity and ecology, Building temperature, Carbon reduction and sequestration, Crime, Economic growth, Education, Enabling development, Flooding, Groundwater recharge, Health, Pumping wastewater, Rainwater harvesting, Recreation, Tourism, Traffic calming, Treating wastewater, Water quality.	Site data (e.g. location, area, baseline option), SuDS components (e.g. number, type and size of trees; area of green roofs, swales, basins and wetlands), Habitat type (e.g. BAP habitat), Number/type of homes and number of people affected by a change in flood risk, amenity value or health, Non-expert qualitative assessment of potential impacts on crime, economic growth, education, tourism and traffic-calming, Avoided drainage / sewerage infrastructure costs, Volume of water infiltrating for groundwater recharge, Change in energy use due to reduced wastewater pumping, Number of properties adopting rainwater harvesting, and household water consumption rates, Change in level and type of recreation due to scheme, Change in wastewater flow and runoff, Current and projected water quality status.	Not specified	1
EMSD	Ecosystem Management Decision Support	GIS data and values	Maps, graphs, diagrams	number of geographic scales	Open access (free)	MS Excel, NetWeaver, the Ecological Management Decision Support (EMDS) ArcView Extension, and ArcView™.	Basic – intermediate GIS skills.	Regulating Provisioning Supporting Cultural	Carbon sequestration, conservation, the design and siting of ecological reserves, ecosystem sustainability, forest management, hydrology, land classification, landscape evaluation, landscape restoration, pollution, social issues in natural resource management, soil impacts, urban growth and development, watershed analysis, wetlands management, wildlife habitat management, wildland fire danger.	Data requirements depend on the resources evaluated. Spatial data, formatted for Arc GIS is required.	Not specified	9
GIVT	Green Infrastructure Valuation Toolkit	Data about the project area and local population statistics in an Excel spreadsheet.	Tables / statistics / reports; Cost-benefit assessment	Site, Local	Open access (free)	Microsoft Excel	Excel skills	Cultural Regulating	Shelter from wind, Reduction of urban heat island effect, Cooling through shading and evapotranspiration, Carbon storage and sequestration, Interception, storage and infiltration of rainwater, Catalyst for community cohesion and pride, Provision of attractive opportunities for exercise, Air pollution removal, Setting for higher value residential and commercial estates, Reduction of absenteeism from work, Tourism attraction, Provision of recreation opportunities, Provision, protection and enhancement of natural habitats, Land management	Size of greenspace, tree cover, green roofs, rights of way, nearby households, community groups, flood risk, site designations, property value, jobs created, index of Multiple Deprivation (IMD), Current land-use, Project context, Land ownership, Heritage value of site	Not specified	1
LUTO	The Australian Land Use Trade-offs model	Maps / GIS data available at a national scale	Maps; Quantitative data on ecosystem services; Tables / statistics / reports	National (place-specific - only Australia)	Proprietary tool	LUTO model	Specific model	Regulating Provisioning Supporting Cultural	Biodiversity and carbon sequestration supply and policy, agricultural production, ecosystem services trade-offs, integrated sustainability assessment, water resource management policy and futures for land-use and ecosystem services.	Fire, drought, climate, soil, water resource biomass, carbon, crop yield, biodiversity, rainfall, runoff, emissions, land use, economic data, etc.	Not specified	24
PGIS	Participatory GIS tool	Personal user information, user-added pins on the online maps, descriptions	None - Information provided to tool developers	Local, Landscape, Regional	Prototype (not yet available)	Access to internet.	Internet use skills	Cultural	Recreation, local history, learning, tranquility, views, beauty and wildlife.	None - just users' opinion.	Low	1

Abbreviation	Name	Input	Output	Scale	Cost	Software	Skills	ES	Specific ES	Datasets	Time	Reference
		of places they value and photographs or evidence.										
ORVal	Outdoor Recreation Valuation Tool	All input data is provided internally by the tool – the user just has to choose an existing green space by clicking on the map, or to specify the land cover of altered or newly created green space.	Maps; Quantitative data on ecosystem services; Tables / statistics / reports; Economic assessment Cost-benefit assessment	Site, Local, Landscape, Regional	Open access (free)	Access to internet.	Internet use skills	Cultural	Recreation	None – all provided by the tool	Low	1
Viridian	Viridian	Maps / GIS data (sourced and managed by Viridian or provided by users).	Maps; GIS databases; Tables / statistics / reports	Local, Landscape, Regional	Proprietary tool	None - the tool is a proprietary tool provided by the developer.	None – tool is run in-house by a consultant	Regulating Provisioning Cultural	Erosion control; Reduction of soil adsorbing pollutants; Reduction of water soluble pollutants; Reduction in air pollution; Reduction in noise nuisance; Reduction in heat island effect; Flood mitigation; Groundwater retention/baseflow control; Carbon sequestration; Primary production - using data provided or simple calculations; mainly for trade-off analysis with other services; Pollination; Biodiversity ; Recreation; Naturalness/tranquility; Proxy-derived indices for health and wellbeing;	Viridian can use a variety of open source, commercial or client datasets.	Low	1

SOURCE:

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