Mass stabilisation and control of erosion rates

Summary of the importance of the assets for ecosystem service provision and drivers of change

			Natural capital assets		
		Importance of asset to service	**Habitats**	**Soils and sediments**	**Land geomorphology**
Drivers of change	Anthropogenic	Industrial or domestic activities			
		Habitat modification			
	Biological resource use	Intensive agriculture and aquaculture			
	Natural hazards/systems	Fire			
		Geological changes			
		Droughts			
		Storms			
		Flooding			
	Climate change impacts	Weather conditions			
		Ocean acidification			

Description

Ecosystem service: *name of ecosystem service and associated CICES information*

Section	Division	Group	Class	Class type	Example
Regulation & Maintenance	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	By reduction in risk, area protected	Vegetation cover protecting/ stabilising terrestrial, coastal and marine ecosystems, coastal wetlands, dunes.

Natural capital assets providing the service: *identification of the key natural capital assets that provide or enable the ecosystem service*

Level 1	Level 2	Level 3	Level 4
Biotic	Biodiversity	Habitats	Coastal
			Inland surface waters
			Woodland and forests
			Habitat complexes
Abiotic	Non-renewable	Soils and sediments	Top-soil
			Sub-soil
			Ocean sediment
	Physical	Land geomorphology	Mountains
			Plains
			Plateaus
			Valleys
			Caves

Narrative description of the asset-service system and underlying asset components: *generic description of the way in which assets provide the ecosystem service, the underlying asset components, and the minimum conditions for maintaining the service flow*

Asset-service system

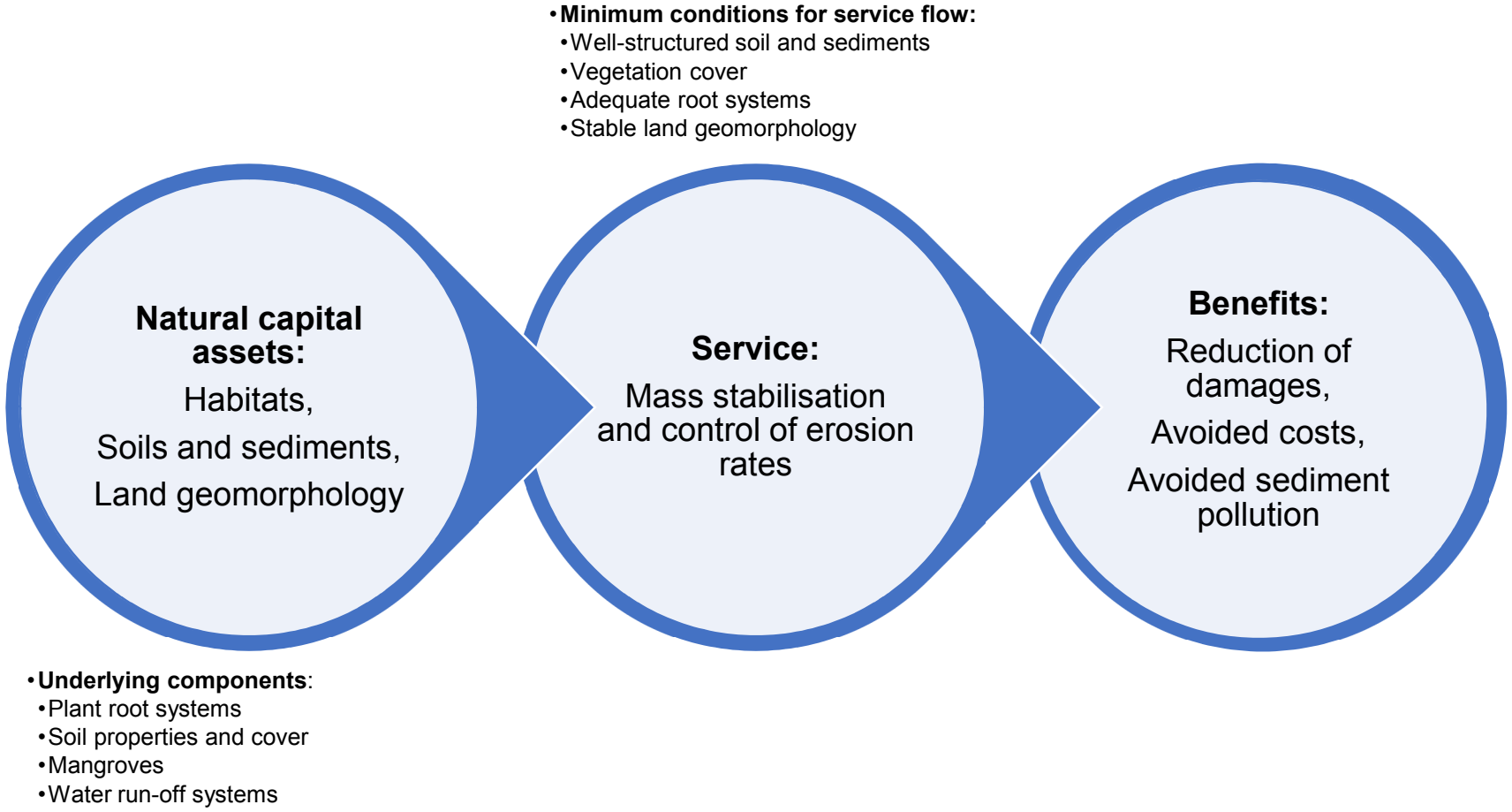
Mass stabilisation and erosion control is delivered through vegetated habitats, land geomorphology, and soils and sediments.

Underlying asset components

- Plant root systems provide slope stability and soil erosion control. Plants shelter and fix soil with their roots, protecting soil against erosion by reducing water runoff. Vegetation also acts as a physical barrier to sediment flow at the soil surface (Durán Zuazo & Rodríguez Pleguezuelo, 2008). Grass roots increase top soil resistance against erosion by concentrated flow.
- The vegetation canopy reduces the energy of raindrops against the soil.
- Top soil cover provided by plants and other organisms. Several species of soil algae form a layer over land, as a form of surface cover, which reduces soil losses in comparison with the losses from bare lands (Booth, 1941).
- Soil properties such as salinity, texture, aggregations, strength, content, and infiltration capacities determine effects of root systems properties (Reubens, Poesen, Danjon, Geudens, & Muys, 2007), resistance to raindrop impact, and resistance to soil break up and gully formation, among others (Ezeabasili, Okoro, & Emengini, 2014).
- Runoff systems manage runoff concentrations to prevent saturation of soil resulting in erosion or landslides (Queensland Government, 2015).
- In coastal systems, mangrove forests protect coastlines from erosion; these dense forests reduce the impact of waves and prevent erosion by increasing friction and reducing storm surge peak water levels. Their root structure reduces erosion (Barbier et al., 2011) and tidal and wave energy are dissipated to lower levels, protecting the shoreline and allowing salt marshes and reeds to grow which in turn reduces erosion (Bell & Lovelock, 2013). Soil condition is an important factors affecting the erodibility of mangrove soils.
- Oyster reefs influence water flow in estuaries and stabilize intertidal sediments in these environments, providing mass stabilization and erosion control (Dame & Patten, 1981).
- Beaches and sand dunes provide sediment stabilization, soil retention in vegetation root structure this control coastal erosion (Barbier et al., 2011).
- Sea grass beds and saltmarshes provide attenuation of waves, stabilization of sediments by roots and rhizomes and their debris, thus controlling coastal erosion (Barbier et al., 2011).

Minimum conditions for maintaining service flow

The minimum conditions for maintaining the service flow are well-structured soils and sediments, stable land geomorphology, sufficient vegetation cover as part of healthy ecosystems, and adequate root systems for the soil type.


• Minimum conditions for service flow:
• Well-structured soil and sediments
• Vegetation cover
• Adequate root systems
• Stable land geomorphology
Natural capital assets:
Habitats,
Soils and sediments,
Land geomorphology
Service:
Mass stabilisation and control of erosion rates
Benefits:
Reduction of damages,
Avoided costs,
Avoided sediment pollution
• Underlying components:
• Plant root systems
• Soil properties and cover
• Mangroves
• Water run-off systems

Drivers of change in the asset-service system

Driver of change	Service, asset, underlying component, or condition affected?	Likely response	Effect on variability of service provision	Human action or natural variation?	Timescale	Spatial characteristics	Reference
Describe the driver influencing or impacting the asset-service system	*Identify which aspect of the asset-service system is influenced or impacted*	*Describe how the service, asset, underlying component or condition is likely to change in response*	*Describe the mechanism by which the driver of change impacts the variability of the service provision, including both immediate and long-term effects*	*Indicate whether it results from a human action or natural variation*	*Identify the timescale on which the change is likely to materialise. Short-term refers to under 1 year, mid-term 3 years and long-term more than 3 years in relation to credit risk.*	*Identify the spatial characteristics for which the change is likely to materialise*	*Sources of information*
Industrial or domestic activities	Habitats, Land geomorphology	Strong wave action by boats. Loss of sand through mining, development and coastal structures. Disturbance of vegetation.	Damage of coastal ecosystems such as mangrove forests and loss of dunes and natural beaches results in reduction of sediment retention and erosion control.	Human action	Short term	Local	(Bell & Lovelock, 2013)(Barbier et al., 2011)
Habitat modification	Habitats	Deforestation, reduction in vegetation cover	Decreases stability and resistance of top-soil. Reduction of erosion control.	Human action	Short-mid term	Local	(Karamage et al., 2016; WWF, n.d.)
	Soils and sediments	Diversion of drainage furrows,	Run-off concentration. Increased soil	Human action	Short-mid term	Local	(Queensland Government, 2015)

		waterways, dam by washes, etc.	break up and vulnerability to water erosion.				
	Land geomorphology	Increase slope length and/or steepness	Slope increase causes increase in speed, power and depth of the runoff carrying more soil with it. Influence nature of the soil making it more susceptible to erosion.	Human action	Short-mid term	Local	(Karamage et al., 2016)
Intensive agriculture and aquaculture	Soils and sediments	Changes soil properties	Changes soil water retention properties thus increases susceptibility to water or wind erosion.	Human action	Short-mid term	Local	(Karamage et al., 2016)
Fire, Droughts	Habitats, Soils and sediments	Damage protective vegetation. Loss of cover due to event induced tree throw. Scalding removes top-soil.	Reduction of erosion control.	Natural/human action	Short-mid-long term	Global	(Bangash et al., 2013)
Flooding, Storms	Habitats, Soils and sediments	Wave action generated by wind and intense storms damages plants and cause	Loss or damage of vegetation can cause reduction in sediment	Natural	Short term	Local	(Bell & Lovelock, 2013)(Hancock, Evans,

		changes in hydrology.	retention capacity. Storm induced tree throw exposes soil and triggers erosion.				McDonnell, & Hopp, 2012)
Geological changes (e.g. landslides, erosion)	Land geomorphology, Habitats, Soils and sediments	Earth movements, alteration of slope steepness, slope length and slope morphology.	Increased soil break up and vulnerability to water erosion. The speed of runoff increases on steep slopes, which increases the power of water to break off and carry soil particles.	Natural	Short term	Local	(Hancock et al., 2012; Queensland Government, 2015) (Bell & Lovelock, 2013) (Karamage et al., 2016)
Weather conditions	Soils and sediments	Rainfall intensity	Risk as heavy raindrops on bare soil causes soil surface to seal increasing erodibility.	Natural	Short term (seasonal)	Local	(Queensland Government, 2015)
Ocean acidification	Habitats	Rising atmospheric CO_2 lowers concentrations of seawater carbonate and reduces calcium carbonate production by corals.	Bleaching and calcification cause mortality and increased coral erosion rates.	Human action	Short-mid term	Global	(Pandolfi, Connolly, Marshall, & Cohen, 2011)

Information and data

Data needs: *Identification of data needed to assess the current or historical state of the asset-service system. Is data more relevant or more available at the level of the service itself or at the level of the assets?*

Service, asset, underlying component, or condition affected?	Description of data need	Asset or service level?
Indicate the aspect of the asset-service system for which data needs are being described	*Identification of data needed to assess the current or historical state of the asset-service system*	*Is data more relevant or more available at the level of the service itself or at the level of the assets?*
Habitats	Comprehensive land cover maps of the areas susceptible to erosion	Asset level
Soils and sediments	Distribution and characterization of areas with high risk soil properties	Asset level
Land geomorphology	Spatial information on areas vulnerable to erosion	Asset level

Driver of change	Description of data need	Asset or service level?
Indicate the driver influencing or impacting the asset-service system	*Identification of data needed to assess the current or historical state of the asset-service system*	*Is data more relevant or more available at the level of the service itself or at the level of the assets?*
Habitat modification	Past and present maps and data on forest cover changes	Asset level
	Models of erosion risk	Asset level
Geological changes	Spatial data on areas at risk of seismic activity etc.	Asset level
Weather conditions, Ocean acidification	Meteorological data and maps, Climatological models of predicted scenarios and changes in areas vulnerable to landslides and erosion	Asset level
Industrial or domestic activities	Spatial data on shipping lanes, recreational boating and recreational activities, infrastructure and industrial activities which have cause alteration of coastal structures or vegetation on areas vulnerable to landslides and erosion	Service level

Intensive agriculture and aquaculture	Location and intensity of activities altering soil properties, vegetation cover, and water runoff	Asset Level
Fire, Droughts	Spatial data on past fire and drought events, spatial data on area vulnerable to fire and drought events	Asset Level
Storms, Flooding	Spatial data and vulnerability data of areas at risk of impact by storms (habitat destruction, runoff, landslides) and flooding	Asset Level

Data sources: *Any existing sources that meet these needs (if some have already been identified, otherwise will be completed in next deliverable)*

- EIONET Erosion Data: http://esdac.jrc.ec.europa.eu/networkcooperations/eionet-erosion-data
- USDA Soil-Erosion: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/?cid=stelprdb1041925
- Pan-European Soil Erosion Risk Assessment (PESERA)
- CORINE Land Cover 2006 is a map of the European environmental landscape based on interpretation of satellite images.
- Global land cover: https://www.esa-landcover-cci.org/
- Using InVEST, *Bangash et al* modelled and mapped ecosystem services to evaluate the impacts of climate change on provisioning (water) and regulating (erosion control) services, at the Mediterranean Llobregat river basin. They used a conceptual framework that focuses on quantifying the benefits associated with changes in ecosystem services as a result of climate change, through a comparison of two climate change scenarios against a base scenario.
- *Karamage et al., 2016*: In this paper, they assessed the potential and soil erosion risk using the Universal Soil Erosion Equation Model developed by the United States Department of Agriculture. When trees are replaced by agricultural plants, these fail to hold the soil and can even exacerbate soil erosion.

Direct links to other ecosystem services: *name and short description including directionality and strength if possible*

- **Surface water:** Water siltation prevented through erosion control. Dependent.

- **Plant-based resources, Fibres from plants, and Plant materials for agricultural use:** Erosion control prevents loss of soil nutrients and structure needed by plants. Dependent and Facilitator.
- **Buffering and attenuation of mass flows:** Maintenance of adequate state of water ways and water bodies (rivers, lakes). Dependent and Facilitator.
- **Hydrological cycle and water flow maintenance:** Prevention of downstream effects like siltation of watercourses and storages. Dependent and Facilitator.
- **Flood protection:** Flood protection by appropriate land coverage; coastal flood prevention by mangroves. Dependent.
- **Storm protection:** Maintenance of natural vegetation that serves as shelter belts. Dependent.

References:

Bangash, R. F., Passuello, A., Sanchez-Canales, M., Terrado, M., López, A., Elorza, F. J., … Schuhmacher, M. (2013). Ecosystem services in Mediterranean river basin: Climate change impact on water provisioning and erosion control. *Science of The Total Environment*, *458–460*, 246–255. https://doi.org/10.1016/j.scitotenv.2013.04.025

Barbier, E. E. B., Hacker, S. D., Kennedy, C. J., Koch, E. W., Stier, A. A. C., & Silliman, B. R. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs*, *81*(2), 169–193. https://doi.org/10.1890/10-1510.1

Bell, J., & Lovelock, C. E. (2013). Insuring Mangrove Forests for Their Role in Mitigating Coastal Erosion and Storm -Surge: An Australian Case Study. *Wetlands*, *33*(2), 279–289. https://doi.org/10.1007/s13157-013-0382-4

Booth, W. E. (1941). Algae As Pioneers in Plant Succession and Their Importance in Erosion Control. *Ecology*, *22*(1), 38–46. https://doi.org/10.2307/1930007

Dame, R. F., & Patten, B. C. (1981). Analysis of Energy Flows in an Intertidal Oyster Reef. *MARINE ECOLOGY -PROGRESS SERIES* , *5*. Retrieved from http://www.int-res.com/articles/meps/5/m005p115.pdf

Durán Zuazo, V. H., & Rodríguez Pleguezuelo, C. R. (2008). Soil-erosion and runoff prevention by plant covers. A review. *Agronomy for Sustainable Development*, *28*(1), 65–86. https://doi.org/10.1051/agro:2007062

Ezeabasili, A. C. C., Okoro, B. U., & Emengini, E. J. (2014). Relative erodibilities of some soils from Anambra. *Sky Journal of Soil Science and Environmental Management* , *3*(8), 83–90. Retrieved from http://www.skyjournals.org/sjssem/Pdf/2014/Oct/Ezeabasili and Okoro pdf.pdf

Hancock, G. R., Evans, K. G., McDonnell, J., & Hopp, L. (2012). Ecohydrological controls on soil erosion and landscape evolution. *Ecohydrology*, *5*(4),

478–490. https://doi.org/10.1002/eco.241

Karamage, F., Shao, H., Chen, X., Ndayisaba, F., Nahayo, L., Kayiranga, A., … Zhang, C. (2016). Deforestation Effects on Soil Erosion in the Lake Kivu Basin, D.R. Congo-Rwanda. *Forests*, *7*(11), 281. https://doi.org/10.3390/f7110281

Pandolfi, J. M., Connolly, S. R., Marshall, D. J., & Cohen, A. L. (2011). Projecting Coral Reef Futures Under Global Warming and Ocean Acidification. *Science*, *333*(6041), 418–422. https://doi.org/10.1126/science.1204794

Queensland Government. (2015). Types of erosion | Environment, land and water | Queensland Government. Retrieved July 7, 2017, from https://www.qld.gov.au/environment/land/soil/erosion/types/

Reubens, B., Poesen, J., Danjon, F., Geudens, G., & Muys, B. (2007, June 26). The role of fine and coarse roots in shallow slope stability and soil erosion control with a focus on root system architecture: A review. *Trees - Structure and Function*. https://doi.org/10.1007/s00468-007-0132-4

WWF. (n.d.). Soil Erosion and Degradation | Threats | WWF. Retrieved July 10, 2017, from https://www.worldwildlife.org/threats/soil-erosion-and-degradation

Surface water for non-drinking purposes

Summary of the importance of the assets for ecosystem service provision and drivers of change

			Natural capital assets
		Importance of asset to service	**Water**
Drivers of change	Anthropogenic	Industrial or domestic activities	
		Habitat modification	
	Natural hazards/systems	Geological changes	
		Droughts	
	Climate change impacts	Weather conditions	

Description

Ecosystem service: *name of ecosystem service and associated CICES information*

Section	Division	Group	Class	Class type	Examples
Provisioning	Materials	Water	Surface water for non-drinking purposes	By amount, type and use	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for domestic use (washing, cleaning and other non-drinking use), irrigation, livestock consumption, industrial use (consumption and cooling) etc.

Natural capital assets providing the service: *identification of the key natural capital assets that provide or enable the ecosystem service*

Level 1	Level 2	Level 3	Level 4
Abiotic	Functional	Water	Surface

Narrative description of the asset-service system and underlying asset components: *generic description of the way in which assets provide the ecosystem service, the underlying asset components, and the minimum conditions for maintaining the service flow*

Asset-service system

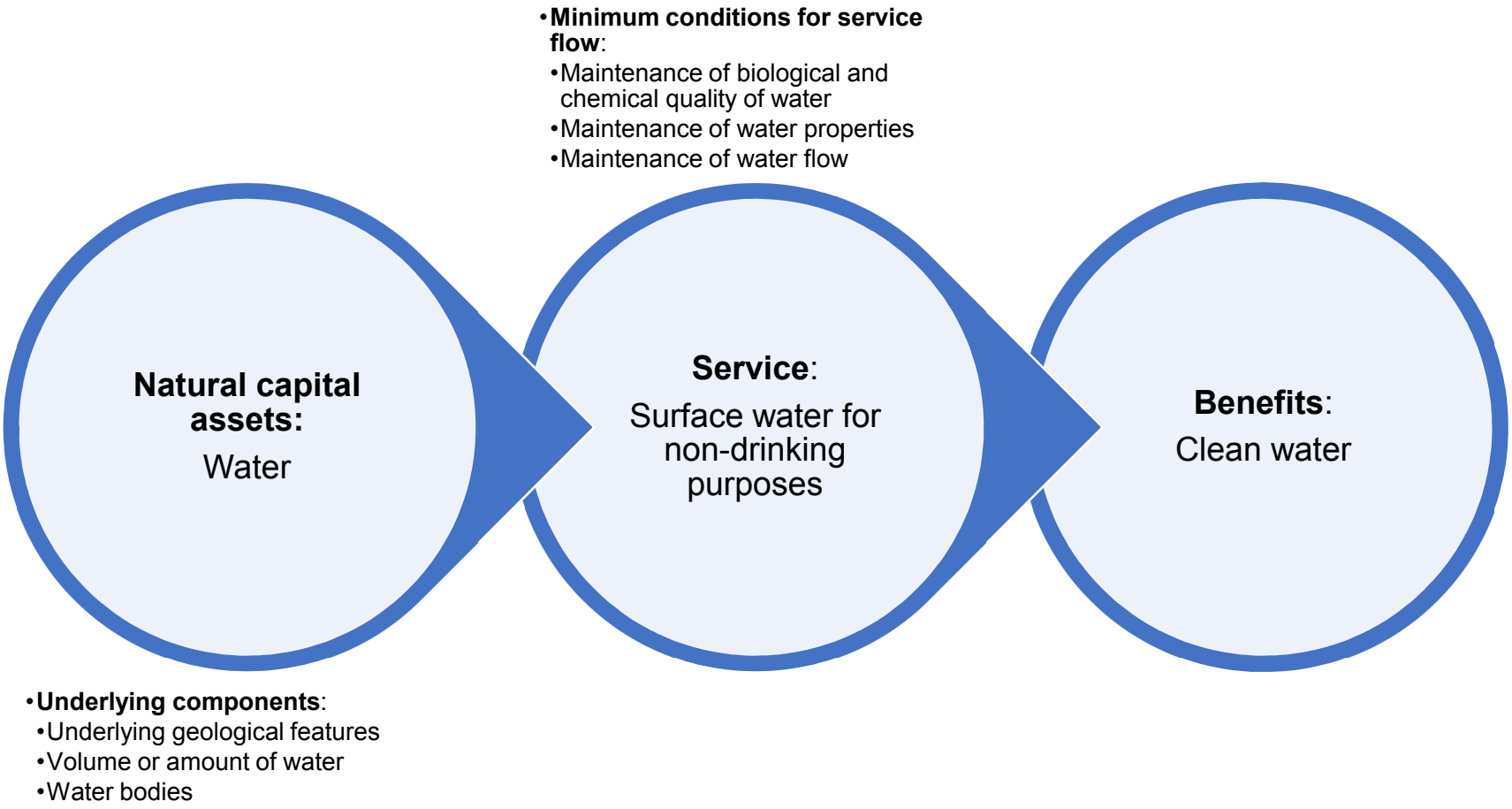
Surface water is provided through freshwater resources from collected precipitation and water flow from natural sources (Khublaryan, n.d.; World Water Assessment Programme, 2009). Surface water is a key resource for many industries, including most notably the agriculture and energy production industries (World Water Assessment Programme, 2009).

Underlying asset components

- Physical water bodies as the assets that enable the provision of surface water. The main types of water bodies are rivers, lakes, streams, reservoirs, canals, transitional waters and coastal waters (European Parliament, 2000; Winter, 1999). In essence they are the "vessels" through which surface water is provided and their physical characteristics result from underlying geological features (Winter, 1999).
- Underlying geological features are the characteristics such as slope, size and shape of river basins, streams, and channels that shape water bodies. These features also influence the flow (i.e. speed) and volume or amount of water that flows through water bodies (Khublaryan, n.d.; Winter, 1999).
- The volume or amount of water flowing through water bodies determines the quantity of surface water provided to catchments or watersheds and the speed at which it is provided (Khublaryan, n.d.; Winter, 1999).

Minimum conditions for maintaining service flow

The minimum conditions to maintain the service flow are maintenance of biological quality (e.g. through the presence of fish), chemical properties, hydromorphological properties such as size and shape of streams and channels, and the flow and quantity of water (e.g. from rainfall) (Department for Communities and Local Government, n.d.).


•Minimum conditions for service flow:
•Maintenance of biological and chemical quality of water
•Maintenance of water properties
•Maintenance of water flow
Natural capital assets:
Water
Service:
Surface water for non-drinking purposes
Benefits:
Clean water
•Underlying components:
•Underlying geological features
•Volume or amount of water
•Water bodies

Drivers of change in asset-service system

Driver of change	Service, asset, underlying component, or condition affected?	Likely response	Effect on variability of service provision	Human action or natural variation?	Timescale	Spatial characteristics	Reference
Describe the driver influencing or impacting the asset-service system	*Identify which aspect of the asset-service system is influenced or impacted*	*Describe how the service, asset, underlying component or condition is likely to change in response*	*Describe the mechanism by which the driver of change impacts the variability of the service provision, including both immediate and long-term effects*	*Indicate whether it results from a human action or natural variation*	*Identify the timescale on which the change is likely to materialise. Short-term refers to under 1 year, mid-term 3 years and long-term more than 3 years in relation to credit risk.*	*Identify the spatial characteristics for which the change is likely to materialise*	*Sources of information*
Industrial or domestic activities	Water	Over use by humans for agriculture, energy generation, other non-drinking purposes, and other industries leads to decrease in water flow and volume.	Decrease in surface water provision. Unless water is returned in equal volumes to water bodies after abstraction, then the volume of surface water provided through water bodies will be reduced by the amount that is not returned.	Human action	Short term - Water abstraction for human purposes occurs on a daily basis and in many areas is resulting in over use.	Local - Restricted to areas of high and unsustainable water use, such as big cities, and large industrial and agricultural areas.	(Mo, Zhang, Mihelcic, & Hokanson, 2011)
Habitat modification	Water	Disturbance of natural water flows and sedimentation in catchments leading to geophysical	Increase or decrease in provision of surface water. If a certain volume of water is removed for industrial use and is not returned	Human action	Short term - Disturbance of water bodies e.g. during construction work, can materialise within	Local - Restricted to areas where water bodies are being disturbed as a result of human activity and/or where water is	(World Water Assessment Programme, 2009; Yang & Dziegielewski, 2007)

		alterations of water bodies Water flow will increase or decrease depending on local conditions.	afterwards, then the total volume of surface water in will be decreased by that volume. Increased sedimentation cuts light to animals, leads to nutrient blooms and loss of oxygen.		a matter of months.	being heavily abstracted and downstream of those areas.	
	Water	Anthropogenic climate change is leading to severe decreases in water flows and alterations to the geological characteristics of water bodies (e.g. desiccation of entire rivers).	Decrease in surface water provision.	Human action	Long term - This impact will materialise over coming decades.	Global - Climate change is occurring on a global scale. Regional and local - Impacts are likely to materialise on a landscape or regional scale, affecting watersheds where water bodies are altered; areas that are already under high water stress will likely be most severely impacted.	(Vörösmarty et al., 2010)
Geological changes	Water	Natural changes in local geo-morphological characteristics	Increase or decrease in surface water provision.	Natural variation	Short term - E.g. immediate impacts of landslides.	Local - This impact will alter watersheds.	(World Water Assessment Programme, 2009)

		of water bodies lead to increase or decrease in volumes of water flow and alter flow direction.			Long term - Gradual changes in slope due to erosion.	Global - Natural erosion occurs on a global scale.	
Droughts	Water	Anthropogenic climate change is leading to more frequent and severe droughts. Severe decreases in water flows and alterations to the geological characteristics of water bodies (e.g. desiccation of entire rivers).	Decrease in surface water provision.	Human action	Long term - This impact will materialise over coming decades.	Global - Climate change is occurring on a global scale. Regional and local - Impacts are likely to materialise on a landscape or regional scale, affecting watersheds where water bodies are altered; areas that are already under high water stress will likely be most severely impacted.	(Vörösmarty et al., 2010)
Weather conditions	Water	This affects watershed- or catchment-level water flows (i.e. increase or decrease in	Increase or decrease in surface water provision.	Natural variation	Short term - This variation is seasonal or annual.	Global - Such variation occurs on a global scale.	(de Wit & Stankiewicz, 2006)

		volume of water flowing through water bodies).					

Information and data

Data needs: *Identification of data needed to assess the current or historical state of the asset-service system. Is data more relevant or more available at the level of the service itself or at the level of the assets?*

Service, asset, underlying component, or condition affected?	**Description of data need**	**Asset or service level?**
Indicate the aspect of the asset-service system for which data needs are being described	*Identification of data needed to assess the current or historical state of the asset-service system*	*Is data more relevant or more available at the level of the service itself or at the level of the assets?*
Water	Models of how slope, size and shape of river basins, streams, and channels change and how this influences water flow	Asset level
	Models of current water flows, and models of current and predicted rainfall patterns at the watershed level	Asset level
	Detailed distribution and flow maps of past and present water courses, rivers, lakes, and other water bodies showing they change naturally over time	Asset level

Driver of change	**Description of data need**	**Asset or service level?**
Indicate the driver influencing or impacting the asset-service system	*Identification of data needed to assess the current or historical state of the asset-service system*	*Is data more relevant or more available at the level of the service itself or at the level of the assets?*
Industrial or domestic activities	Models or maps of current trends in water use, allowing to anticipate effects on water volumes and flows	Service level
Geological changes	Models or maps showing which areas are most at risk of landslides and steady erosion to identify which areas are likely to experience changes in surface water provision through alteration of water bodies	Service level
Droughts	Models or maps of areas or even specific water bodies that are more likely to experience droughts in the future	Service level
Habitat modification	Models of current and predicted land use changes and information on likely repercussions on water bodies, geological features, and water volumes and flows	Service level
Weather conditions	Trends in water flows, rainfall patterns and models of predicted changes in weather conditions (e.g. changes in seasonal and annual rainfall and climate conditions)	Service level

Data sources: *Any existing sources that meet these needs (if some have already been identified, otherwise will be completed in next deliverable)*

- United Nations World Water Development programme
- European Union river flow assessment and indicators
- https://www.eea.europa.eu/data-and-maps/indicators/river-flow-3/assessment
- Dickson et al. (2014)

Direct links to other ecosystem services: *name and short description including directionality and strength if possible*

- **Materials from plants, algae and animals for agricultural use:** plants, algae and animals are all highly dependent on water, including surface water. Dependent.
- **Ground water for non-drinking purposes:** surface water bodies are sometimes dependent on ground water sources for replenishment, Facilitator.
- **Plant-based resources:** plants are highly dependent on water, including surface water, for growth. Dependent.
- **Animal-based resources and energy:** animals are highly dependent on water, including surface water, for growth and survival. Dependent.
- **Bio-remediation by micro-organisms, algae, plants, and animals**; **Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals**; **Dilution by atmosphere, freshwater, and marine ecosystems:** surface water quality is dependent on bio-remediation. Facilitator.
- **Mass stabilisation and control of erosion rates:** surface water is dependent on erosion control for maintenance of quality; lower rates of erosion lead to cleaner surface water, which improves its quality for use by industry and reduces the costs of water purification. Facilitator.
- **Buffering and attenuation of mass flows:** water bodies such as lakes, rivers, and streams are responsible for transport and storage. Dependent.
- **Hydrological cycle and water flow maintenance:** surface water provision is intrinsically dependent on the hydrological cycle and maintenance of flows. Facilitator.
- **Flood protection:** the natural geomorphological characteristics of water bodies can sometimes either help to protect from floods or facilitate flooding. Dependent.
- **Chemical condition of freshwaters:** surface water quality is dependent on the same processes that enable maintenance of good freshwater quality. Facilitator.

References:

de Wit, M., & Stankiewicz, J. (2006). Changes in surface water supply across Africa with predicted climate change. *Science*, *311*(5769), 1917–1921. https://doi.org/10.1126/science.1119929

Department for Communities and Local Government, U. (n.d.). Water supply, wastewater and water quality - GOV.UK. Retrieved July 5, 2017, from https://www.gov.uk/guidance/water-supply-wastewater-and-water-quality

Dickson, B., Blaney, R., Miles, L., Regan, E., van Soesbergen, A., Väänänen, E., … Martin, M. (2014). *Towards a global map of natural capital: Key ecosystem assets*. Nairobi, Kenya. Retrieved from http://wcmc.io/towards_a_global_map_of_natural_capital

European Parliament, C. of the E. U. (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. *Official Journal of the European Communities*. Retrieved from http://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF

Khublaryan, M. G. (n.d.). Surface waters: Rivers, streams, lakes, and wetlands. In *Encyclopedia of Life Support Systems* (pp. 1–7). Retrieved from https://www.eolss.net/Sample-Chapters/C07/E2-03-01-03.pdf

Mo, W., Zhang, Q., Mihelcic, J. R., & Hokanson, D. R. (2011). Embodied energy comparison of surface water and groundwater supply options. *Water Research*, *45*, 5577–5586. https://doi.org/10.1016/j.watres.2011.08.016

Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., … Davies, P. M. (2010). Global threats to human water security and river biodiversity. *Nature*, *467*, 555–561. https://doi.org/10.1038/nature09549

Winter, T. C. (1999). Relation of streams, lakes, and wetlands to groundwater flow systems. *Hydrogeology Journal*, *7*, 28–45. Retrieved from https://link.springer.com/content/pdf/10.1007%2Fs100400050178.pdf

World Water Assessment Programme. (2009). *The United Nations World Water Development Report 3: Water in a changing world*. Paris. Retrieved from http://unesdoc.unesco.org/images/0018/001819/181993e.pdf

Yang, X., & Dziegielewski, B. (2007). Water use by thermoelectric power plants in the United States. *Journal of the American Water Resources Association*, *43*(1), 160–169. https://doi.org/10.1111/j.1752-1688.2007.00013.x