3. THE HIERACHICAL FRAMEWORK

Many hierarchical approaches have been proposed to support better understanding of the functioning of river catchments, corridors and networks. In chronological order, some well documented examples include Frissell et al. (1986); Montgomery and Buffington (1998); Montgomery (1999); Habersack (2000); Thomson et al. (2001); Snelder and Biggs (2002); Kondolf et al. (2003); González del Tánago and García de Jalón (2004); Brierley and Fryirs (2005); Thorp et al. (2006); Dollar et al. (2007); Beechie et al. (2010); Rinaldi et al. (2012, 2013); Wang et al. (2012). Each of these was developed with a particular application or set of applications in mind.

For the present application, the hierarchy of spatial units within which relevant properties, forms and processes can be investigated to understand and assess hydromorphology is presented in Figure 3.1. The units are arranged according to their relative size (indicative spatial scale). The reach is the key spatial scale at which the mosaic of features found within river channels and floodplains (i) responds to the cascade of influences from larger spatial scales and (ii) is influenced by interactions and feedbacks between geomorphic and hydraulic units and smaller elements such as plants, large wood and sediment particles within the reach.

Table 3.1 also presents the hierarchy of spatial scales, giving a definition of each scale, the criteria that are used to delineate the spatial units at each scale and some possible data sources to support delineation. Table 3.2 provides more information on the pan-European data sources referred to in Table 3.1. Geomorphological interpretation or modelling approaches can then be used to link the scales through upscaling or downscaling and thus understand how properties at different scales influence properties at other scales.

Application of the hierarchy may vary according to catchment size and management application:

- For catchment assessment and management purposes, the aim should be to subdivide the entire catchment into a complete set of units at all spatial scales from catchment to reach
- However, in large catchments, it may not be possible, at least in the first instance, to achieve a complete set of units for the entire catchment. Under these circumstances, it is necessary to subdivide the catchment to the scale of its major landscape units, and then isolate representative subcatchments within each landscape unit and linking segments and reaches along the main channel and major tributaries for detailed analysis.
- If the purpose is to focus on a particular reach or segment and a complete catchment assessment has not been completed, then a minimum assessment needs to focus on spatial units that contain and are immediately upstream of the reach under consideration.

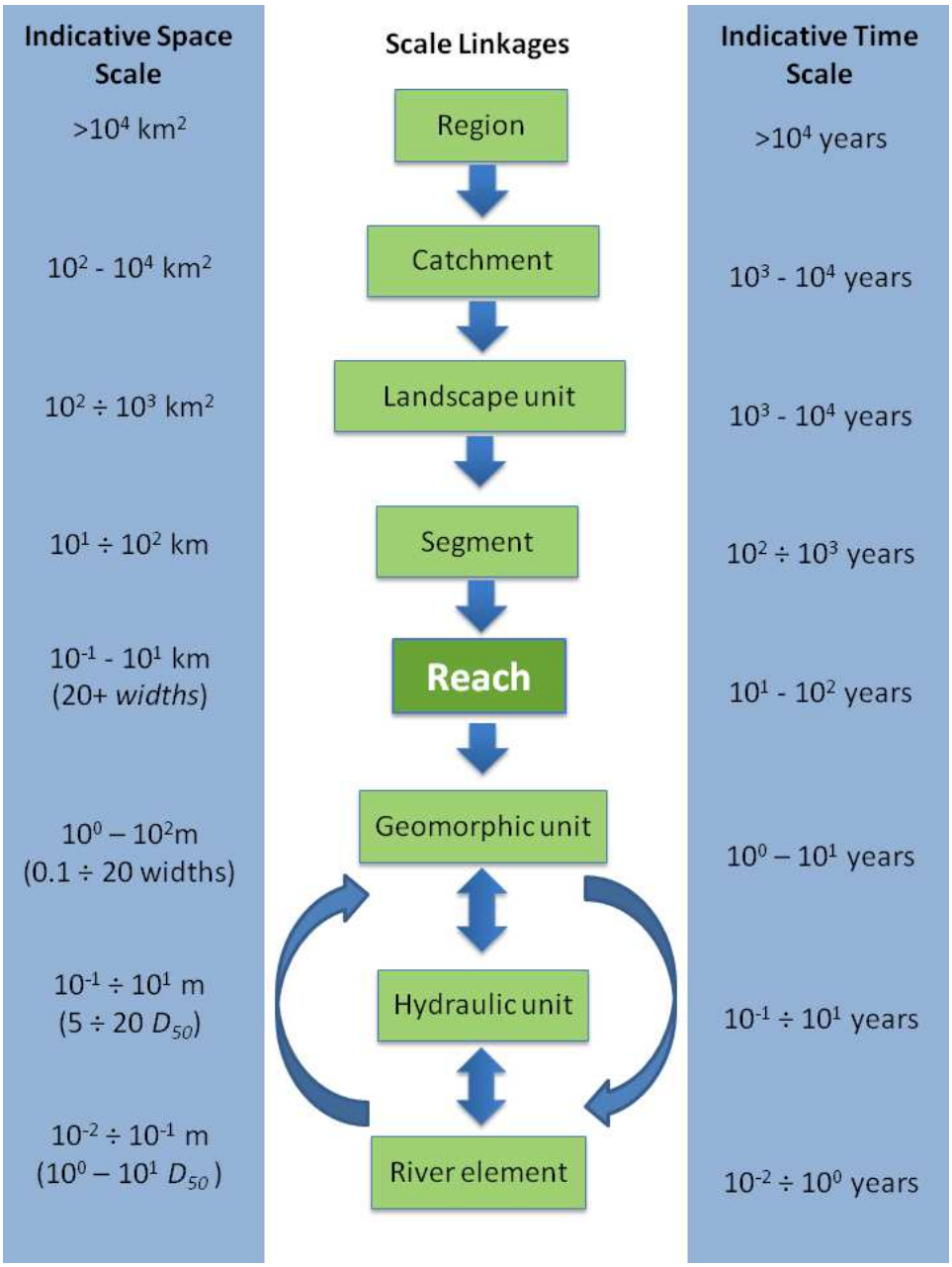

Figure 3.1: Hierarchy of spatial scales for the European Framework for Hydromorphology, including indicative spatial dimensions and timescales over which these units are likely to persist.

Table 3.1 Spatial Units within the Framework: Definitions, Delineation Criteria and Potential Data Sources and Methods

Spatial Unit *(equivalent terms)*	**Definition / Description**	**Delineation criteria (#)**	**Methods and Data Sources (#)**
Region (Ecoregion, Biogeographical region)	Relatively large area that contains characteristic assemblages of natural communities and species that are the product of broad influences of climate, relief, tectonic processes, etc.	Differences in main climatic variables and distribution of main vegetation types as shown in maps delineated at European scale (see sources column)	www.globalbioclimatics.org, using Biogeographic Region and Sub-Region
Catchment (Drainage basin, Watershed)	Area of land drained by a river and its tributaries. .	Topographic divide (watershed)	Digital Elevation Models (e.g. SRTM, ASTER GDEM) using GIS algorithms to delimit the divide EU-wide CCM2 River and Catchment Database (v2.1)
Landscape Unit (Physiographic Unit)	Portion of a catchment with similar landscape morphological characteristics (topography/landform assemblage).	Topographic form (elevation, relief – dissection, often reflecting rock type(s) and showing characteristic land cover assemblages)	GIS overlay of some of the following in the stated order of priority (1) Digital Elevation Model (e.g. SRTM, ASTER GDEM) (2) Geological maps (One Geology Europe) (3) CORINE Land Cover (4) Supporting information from: Google Earth / Orthophotos
River segment (River sector)	Section of river subject to similar valley-scale influences and energy conditions.	Major changes of valley gradient Major tributary confluences (significantly increasing upstream catchment area, river discharge) Valley confinement (confined, partly-confined, unconfined)	(1) Major segments are identified by applying GIS tools to a DEM with river network overlay, to define downstream breaks in valley gradient (and width) and in upstream contributing area. (2) Major segments may be subdivided according to valley confinement interpreted from DEMs Google Earth images Orthophotos

River reach	Section of river along which boundary conditions are sufficiently uniform that the river maintains a near consistent internal set of process-form interactions. (A river segment can contain one to several reaches)	Channel morphology (particularly planform) Floodplain features (minor changes in bed slope, sediment calibre, may be relevant) Artificial discontinuities that affect longitudinal continuity. (e.g. dams, major weirs / check dams that disrupt water and sediment transfer)	Segments are subdivided into reaches by visual interpretation of consistent river and floodplain (bio) geomorphic pattern using Google Earth Orthophotos Multi-spectral remotely-sensed data Lidar data (Field reconnaissance can provide useful confirmation / additional data)
*Geomorphic unit (*Morphological unit, Mesohabitat, Sub-reach)	Area containing a landform created by erosion and/or deposition inside (instream geomorphic unit) or outside (floodplain geomorphic unit) the river channel. Geomorphic units can be sedimentary units located within the channel (bed and mid-channel features), along the channel edges (marginal and bank features) or on the floodplain, and include secondary aquatic habitats within the floodplain. Some geomorphic features (biogeomorphic units) are formed in association with living and dead (e.g. large wood) vegetation as well as sediment.	Major morphological units of the channel or floodplain distinguished by distinct form, sediment structure / calibre, water depth/velocity structure and sometimes large wood or plant stands (e.g. aquatic / riparian, age class)	Requires field survey but preliminary analysis can use: Google Earth Orthophotos Multi-spectral remotely-sensed data Lidar data
Hydraulic unit	Spatially distinct patches of relatively homogeneous surface flow and substrate character. A single geomorphic unit can include from one to several hydraulic units.	Patches with a consistent flow depth / velocity / bed shear stress for any given flow stage and characterized by narrow range in sediment calibre	Requires field survey
River element	Elements of river environments including individuals and patches of sediment, plants, wood, etc.	Significant isolated elements creating specific habitat or ecological environmentso	Requires field survey

(#) All spatial scales equal to or greater than the reach scale may be delineated using secondary sources and a desk-based analysis – types of data are suggested here.

Table 3.2 Pan-European Data Sources that can be used for Delineating Spatial units at the Reach Scale and larger

Data set / source	Description	Web link	Type	Cost/Availability
Synthesis of several primary data sources	Biogeographic Regions and Subregions	www.globalbioclimatics.org http://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-europe-2001	Maps of Regions	Free
ASTER GDEM	30m resolution , 7-14m vertical accuracy	http://asterweb.jpl.nasa.gov/gdem.asp	Topographic	Free
NASA SRTM3 DEM	90m resolution, 10m vertical accuracy	http://www2.jpl.nasa.gov/srtm/ http://glovis.usgs.gov/	Topographic	Free
JRC CID Portal	High resolution (1,2,5,10m) satellite imagery, spatial coverage and dates vary	http://cidportal.jrc.ec.europa.eu/imagearchive/main/	Channel planform, vegetation/land use	Free
Image 2000 Satellite Imagery	12.5m resolution (panchromatic), 25m (multispectral)	http://image2000.jrc.ec.europa.eu/index.cfm/page/image2000_overview	Channel planform, vegetation/land use	Free
LandSat (4,5,7) Satellite Imagery	30m resolution (15m from 1999), 1982-present	http://earthexplorer.usgs.gov/ http://glovis.usgs.gov/	Channel planform, vegetation/land use	Free
ASTER Satellite Imagery	30m resolution	http://asterweb.jpl.nasa.gov/index.asp	Channel planform, vegetation/land use	£30 per 60km2
Declassified Satellite Imagery (Corona, KH-7, KH-9)	1'-50' resolution, 1960-1980, spatial coverage varies	http://earthexplorer.usgs.gov/	Channel planform, vegetation/land use	$30 per frame
European Water Archive	Flow data (daily/monthly) from 3800 gauging stations, 441 are near-natural catchments	http://www.bafg.de/GRDC/EN/04_spcldtbss/42_EWA/ewa.html	Hydrology	Free
CCM2 Database	Pan-European database of river networks and catchments	http://ccm.jrc.ec.europa.eu/php/index.php?action=view&id=23	Channel network, catchment boundaries and characteristics	Free
Corine Land Cover	Land cover data (1990, 2000, 2006), resolution = 100 m	http://www.eea.europa.eu/data-and-maps	Land use	Free

One Geology Europe	Surficial geology coverage for Europe, resolution varies	http://www.onegeology.org/	Geology	Free
European Soil Portal (groundwater)	Groundwater resource maps of Europe (38 map sets at 1:500000 scale)	http://eusoils.jrc.ec.europa.eu/ESDB_Archive/groundwater/gw.html#data	Aquifers	Free
European Soil Portal (soils)	Soil data (shapefiles), 1km resolution	http://eusoils.jrc.ec.europa.eu/ESDB_Archive/ESDB/index.htm	Soil	Free
European Soil Portal (K erodibility factor)	10km resolution raster data set of USLE K-factor (t.ha.h)/(ha.MJ.mm)	http://eusoils.jrc.ec.europa.eu/library/themes/erosion/Erodibility/	Soil erodibility	Free
European Soil Portal (PESERA soil erosion estimates)	Modelled soil erosion (t ha-1 yr-1) estimates at 1 km resolution	http://eusoils.jrc.ec.europa.eu/ESDB_Archive/pesera/pesera_download.html	Sediment delivery	Free
JRC Forest Cover Maps	30m resolution (1990, 2000, 2006), derived from LandSat and Corine data	http://forest.jrc.ec.europa.eu/download/data/	Vegetation	Free

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