Chapter 5: Assessing the land-water environment

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Introduction

The BlueHealth project aims to investigate links between environment, climate and health. In order to provide places where people can enjoy access to water and also obtain many of the health and well-being benefits associated with blue spaces, it is important to be able to make effective links from a planning and design perspective. A tool which evaluates a place in a holistic way, through integrating a number of domains (such as the social, physical or ecological), and which enables the positive and negative aspects to be identified is needed. Where some important connections or specific social, spatial, functional, aesthetic, hydrological or ecological aspects are missing or found to be negative, then planners and designers can use this information to improve places and through this contribute to improving the potential for physical and mental health and well-being of target populations.

This chapter presents the background to the development of the BlueHealth Environmental Assessment Tool (or BEAT for short) and describes its structure and how to use it and also illustrates its application in some worked examples. The tool itself is available online at www.beat.bluehealth.tools/.

Objectives for the tool

The BEAT tool presented here aims to provide a comprehensive method of assessing all the relevant domains related to 'blue spaces' (any outdoor space that prominently features water and which individuals may experience, whether by direct contact in, on or by the water or by indirect means such as seeing it). The tool is designed primarily for identifying the extent to which a particular blue space provides opportunities for obtaining exposure to water but also what impacts there might be on the environment itself and what hazards are present (or potentially present) for both environment and people (the tool also makes strong connections with the decision support tool presented in Chapter 9). It can be used as a means of collecting data about blue spaces for monitoring purposes (as an indicator set to be used over time); as a starting point in a planning and design project for upgrading, restoring or providing new access to waterfront landscapes; or for a post-occupancy evaluation of a built project.

The tool is designed to be used by two distinct groups. The first comprises experts, such as landscape architects, ecologists, recreation planners, urban planners or hydrologists. It is expected that these experts know the relevant domains in depth and that they have sophisticated methods or instruments for assessing many of the factors objectively (such as hydrological or ecological aspects), or else they have experience of applying subjective factors in a rational and repeatable way (for example, aesthetic and design factors). A team of experts might be used to collect and interpret the data, to relate data collected on site to that available from monitoring stations (for example, air or water pollution) or from other statistical sources (such as socioeconomic data about local residents) and, most importantly, to relate the factors to one another and not just treat them separately. The second group comprises local

community or citizen groups who have an interest in their local environment and want to be able to check aspects such as how safe it is for their children to go swimming and to educate themselves in urban ecology, as well as to help themselves develop a project for the improvement of a local place. School student use is also a possibility, perhaps for in science projects or in studies of the local environment, its hazards and changing condition.

It is also possible that experts (for example, responsible professional staff in a municipality) might encourage communities to participate in 'citizen science' and work together to collect data and to monitor sites. Such an approach is often employed in the collection of data on urban wildlife (such as counting birds or other animal or plant species). Communities often have members who are themselves rather knowledgeable about some areas, such as bird watchers or fishermen, whose expertise or tacit knowledge might be capitalised upon for the purpose of collecting good quality data.

The tool is therefore designed with these two target groups in mind. The data expectations from the experts are higher than for the community users, and the functional interface of the tool differs. The community-level tool assumes less knowledge, and the interface presents the sections in a simpler and easier-to-follow way which might be suitable for school students or local people with no specific environmental or design background. As such, it also provides a learning platform.

Those elements of the tool that are objective and measurable on site can be administered by a single person. For less objective – or more qualitative – elements where professional experience is required, it is necessary to involve a minimum of two individuals so that the independent assessments of each assessor can be compared prior to agreement or moderation of final scores. This also adds to the overall reliability of the tool.

In developing this tool, we did not intend to create something from scratch or without consideration of other, already developed and tested tools (which, however, in the main, do not cover blue spaces very well). Rather, we conducted a review of existing tools and extracted from these a number of aspects related to content, structure and application methods that were considered most applicable and relevant in terms of blue spaces.

The tool itself covers two linked but separately assessed sections: one for the terrestrial part of a blue space and one for the aquatic part. The conceptual thinking and presentation of the results are different for each, and they were developed by separate teams, one of landscape architects and one of water ecologists. They have been incorporated into one functional tool and user interface, available at www.beat.bluehealth.tools/.

Research informing the development of the BEAT

There are a variety of tools available for assessing the character and uses of places. These have typically been designed for specific aspects or particular kinds of places such as woodlands, parks, residential areas or beaches, for example. Therefore, in developing the BEAT, we searched for existing tools and then reviewed them to see what aspects they covered, how they assessed a place or site, who they were aimed at and how the results were presented. We looked for tools that covered related aspects, were well documented, were applied in practice and/or were developed as part of a project and written up in a scientific journal, as well as being available in English. We found 17 tools which fitted these criteria (see Appendix 1). They are all relatively recent – from the early 2000s usually – reflecting the rise in interest in the field in that period as well as the need to develop means of measuring sustainability and so on following all the Millennium goals and requirements and UN, WHO and EU initiatives and so on.

We found a number of assessment tools, some freely available and well used, others more specific and presented in academic papers but not necessarily widely applied. Many of them make reference to others which they have used to help or guide their development, which accounts for the convergent evolution apparent in many of them. They are all, to some extent at least, intended for use by both professionals and community groups, although some have two versions and are approached a little differently. The type of place or space varies, with no system looking comprehensively at the land-water interface from all possible angles. The scale varies, but most are for use at local spatial levels. There is a great deal of commonality in the factors assessed in each tool, although some aspects are

deeper or shallower than others depending on the tool and its intended scope. Tools dealing with water are far fewer than those dealing with land. Most tools are structured with a number of main domains and then a set of factors or aspects within each. This makes them easier and more logical to understand and follow, as well as to compare different domains in order to achieve a full picture of the place under assessment. The use of rating scales of various sorts, together with qualitative descriptions and yes/no answers, are typical ways of assessing the environments and lead to clear ways of presenting comparable results. These have led, too, to the use of spidergrams and other similar diagrams as means of presenting results in easy-to-assimilate forms. Important for successful application of all tools is an accompanying set of instructions, whether provided in a manual, training videos, online resources or games. The tool development is reported in Mishra et al. (2020) for readers interested in this in more detail.

There are gaps in the coverage of environments which the BEAT aims to close. We also provide two versions, one for professionals and one for community groups, fully supported by instruction manuals and worked examples. We also present an online web-based tool for inputting data and producing the results in digestible form.

BEAT conceptual framework

Since the objective of the BEAT is not only to provide a tool for assessing blue spaces but to ensure that such spaces promote health and well-being, it is necessary to ensure that there is a theoretical connection. Therefore, lying behind the practical development and application of the new BEAT is the “person-environment fit” theory (Korpela et al., 2008) which helps us to define the blue space attributes that benefit health and which highlights the importance of key blue space physical environmental features (see Figure 5.1). Physical environments influence human health in

Figure 5.1

The person-environment interaction model for Blue Space and health outcomes which forms the theoretical basis for the BEAT. On the left are the blue space attributes assessed by the tool, and the rest of the model shows the pathways which lead to the expected health outcomes

(Source: Himansu Sekhar Mishra and Anna Wilczyńska)

part through psychological and physiological restoration (Berto, 2014) that in turn depends on the capacity of both the people and the place to support various health outcomes (Stokol, 2003). These transactional parameters can be categorised into two ontological dimensions: *environmental affordance* (Hartson, 2003) and *environmental affect* (Bakker et al., 2014) (Figure 5.2).

Figure 5.1 presents the potential relationship between blue space attributes and health determinants. Health determinants are the “active ingredients” in the environment that impact health and well-being positively or negatively. Within this, the properties of the space generate affordances which support a range of potential activities (Gibson, 1979), and in turn, these may promote behavioural and psychological responses. Blue space interventions, policies and management practices that originate from within the “person” dimension tend to improve physical characteristics that in turn enhance the blue space affordances and affects. Conversely, terrestrial and aquatic environmental conditions, qualities and impacts may independently and directly affect a population’s exposure to blue space, positively or negatively influencing behaviour and psychology.

Figure 5.2 highlights the importance of physical attributes of the outdoor environment within the nature-health relationship and elaborates on mechanisms that may influence pathways to health (Frumkin et al., 2017; USDA, 2018, Hartig et al., 2014). The relationship between blue space exposure and health determinants is mediated by the perceived affordances and blue space effects. The dimensions of affordances (physical, functional, sensory and cognitive) and dimensions of affect (pleasure, arousal and control and influence) may play a role in reinforcing the link between nature and health.

Figure 5.2

An interaction model for Blue Space use for physical activities and relaxation. The unshaded boxes are potential blue space benefits unrelated to the person-environment interaction

(Source: Himansu Sekhar Mishra and Anna Wilczyńska)

Development of the BEAT structure

When reviewing and analysing the 17 tools as noted previously, a set of environmental aspects emerged to explain the structure, application and place characteristics and to provide an ontological framework. Generally, tools have a hierarchical structure based on a set of major topic themes or *domains* within which a selection of sub-themes or *aspects* can be found. These vary from tool to tool in how they are grouped and organised. Depending on the focus of a particular tool, some domains and aspects are represented in greater depth than others. The use of an equally weighted domain/aspect structure is one way of enabling the assessment results to be comparable and to be able to see where a site may score higher or lower in different aspects within a single domain and then across different domains. This also helps when making decisions about what to do with a place or space and where to prioritise actions such as physical or social interventions to improve it.

We selected the set of domains and aspects for the BEAT, identifying a number of areas which were weakly represented in the tool review in relation to the land-water interface, this being the focus of our new tool. We set up an overarching structure of *domains* as a relatively simple basis and then ensured, by reference back to the tool review and the categorisation of environment-behaviour interaction dimensions, that all *aspects* were covered.

BEAT structure and content

When considering how tools were applied, there tended to be two or three stages, such as a preliminary desk study to obtain information (maps, data, etc.) and to establish the site boundary to be assessed in context, followed by an initial visit to obtain first impressions and a general overview, followed by a more detailed on-site assessment. The BEAT follows this approach in four steps: 1) preliminary data about the site (macro-level assessment), 2) general site description (for first impressions), 3) on-site survey (micro-level assessment). The separate water/aquatic ecology part of the BEAT (Step 4) is presented separately due to its different origins later in the chapter.

BEAT structure for macro-level assessment

STEP 1: PRELIMINARY DATA ABOUT THE SITE

The preliminary data-gathering step is primarily a desktop study to explore the blue space context, type and surrounding components, including geographical attributes and regional climate, site accessibility and the role of the site in the city or regional level blue space structure. Locational and contextual blue space aspects identified at this stage are:

1. Location
2. Name of site, survey grid reference/GPS coordinates, area (ha)/length (m or km)
3. Blue space type(s) (according to a list used in the BlueHealth project)
4. Site context
 - a. Brief description of the site, its current uses and general setting
 - b. Historical information about the site
 - c. Nature protection status, if any (Natura 2000, etc.)
 - d. Symbolism and memory associated with the area, if available
 - e. General description of the surrounding landscape and setting (built form, natural elements, etc.)
 - f. General description of the water body and its wider connectivity in the hydrological system (character of the water, tidal or flow conditions, general quality)
 - g. Accessibility to the site (terrestrial and water-borne)

5. The residential character of the neighbourhood (if relevant)
 - a. Property types and ownership
 - b. The population within 100 m, 500 m, 1 km (based on different walking times)
 - c. Socioeconomic status
 - d. Ethnic composition (may be a problem in some locations due to local sensitivities or absence of data – should be checked)
 - e. Age structure of the population
6. Other green/blue connectivity (e.g. other green/blue spaces within 100 m, 500 m, 1 km of the site)
7. Tourism and recreational infrastructure and attractions within 1 km of the site

STEP 2: GENERAL SITE DESCRIPTION (FOR FIRST IMPRESSIONS)

This stage records a general description of the site under assessment, comprising a site map marked with different sub-areas or zones and calculated as percentages of the site. For a larger site, it may be necessary to subdivide it into major zones and repeat this for each.

The first impression of the site is recorded based on the condition and activities taking place at the time of the survey. This step is important because for visitors, a first impression says a lot about a place and affects attitudes towards it, and it also helps to put the detailed micro-assessment in context later on. Table 5.1 presents the aspects to be considered in this step.

BEAT structure for micro-level assessment: on-site survey

The main part of the assessment is conducted on-site after the initial walk-around and first impressions have been recorded in Step 2. This survey can be repeated, for example, before and after implementing a new design intervention or at different times of the year when activities may be different (e.g. winter vs. summer). Each domain has a specific set of aspects to be assessed and ways of assessing them.

Table 5.1 Aspects of the environmental domain

<i>Aspects</i>	<i>Assessment criteria</i>
Open water	Fresh/salt Tidal/non-tidal Running/still Depth
Riparian/water margin structure	Slopes (gradient) Embankments
Water edges	Trees Reeds Shingle Sand Concrete walls Rip-rap (large boulders or concrete blocks piled up to form a breakwater)
Terrestrial land cover	Grass Woodland Shrubs Hard surfaces
Paths and facilities within the site	Paths and benches Water access structures Buildings

SOCIAL DOMAIN

The social domain of the BEAT draws on different environment-behaviour interaction dimensions and includes key aspects of use and activities, safety and security and information and education. Use and activity indicate place support for different behavioural dimensions as well as social activities and cohesion. While perceived community and personal safety and security enhance or inhibit the use of a place, information and education support social benefits and help to promote use. The BEAT social domain aspects are presented in Table 5.2.

AESTHETIC DOMAIN

The spatio-psychological dimension focuses on visual aesthetics, place experience and comfort, as well as such non-visual aesthetics as place attributes that aid psychological restoration. The BEAT aesthetic domain aspects are presented in Table 5.3.

PHYSICAL DOMAIN

The physical domain draws on the spatio-physical, spatio-behavioural and management aspects within the environment-behaviour interaction model. Access and circulation relating to blue space can be enhanced through improving site accessibility, that is, site locations and access points, vehicular access and parking provisions and access and circulation within the site through creating access infrastructure, that is, the walking and cycle path network and accessibility to water and play areas. Ease of access for people with disabilities is an important determinant for place

Table 5.2 **Aspects of the social domain**

<i>Aspects</i>	<i>Assessment criteria</i>
Aspect 1: Use of the site and activities	<ul style="list-style-type: none"> Activities taking place on land and on or in the water (direct evidence). Negative or anti-social activities, if seen, should also be recorded Activities taking place from indirect evidence (if there are few or no people on the site at the time of the assessment visit), such as traces left behind or from talking to people on land and on or in the water An estimate of how many and what kind of people are using the site (age and gender but not ethnicity) <p>NB: Repeated visits across the year will reveal much more about the patterns of use.</p>
Aspect 2: Information and education	<ul style="list-style-type: none"> Presence, and usefulness of information such as signs Presence and functionality of way-marking or directional signs Presence and clarity of codes of conduct/rules and regulations Interpretive structures giving information of value to visitors of a cultural, historical or environmental nature Accessibility of information for people with different types of disability Presence of information in a range of languages
Aspect 3: Safety and security	<ul style="list-style-type: none"> Physical safety and security against traffic and along water edges Presence of water safety equipment and lifeguards Presence and functionality of lighting Sense of general security against crime or anti-social behaviour Presence of vandalism or damage signalling lack of security Presence of threatening people Signs of alcohol or drug use

Table 5.3 **Aspects of the aesthetic domain**

<i>Aspects</i>	<i>Assessment criteria</i>
Aspect 1: Visual condition of the surroundings of the site	<ul style="list-style-type: none"> • Visual quality of buildings and other structures visible along the site boundaries (landside) • Screening of off-site eyesores by trees and vegetation (see guidance for definition of an eyesore) • Quality of views out from the site across the water • Sense of openness and scale of water views • Presence of focal points visible from the site • Visual pollution (such as garish advertising)
Aspect 2: Visual quality of the site	<ul style="list-style-type: none"> • Quality of views within the site • Quality of views to the site from the water • Visual quality of built structures within the site • Attractiveness of vegetation on the site • Light pollution at night (from outside sources) • Sense of wildness
Aspect 3: Non-visual aesthetic aspects	<ul style="list-style-type: none"> • Smells and olfactory pollution • Sounds and noise pollution • Sense of atmosphere: wind, moist air, etc. • Feeling of tranquillity or calmness

success, which includes universal design considerations for paths and access routes and access to water, facilities and amenities. The terrestrial and water-based recreation structure aspect assesses all public, recreational and sports amenities and facilities present within the blue space. The management aspect covers site maintenance and sustainable practices. This domain covers the terrestrial part of the site and includes all constructed elements as presented in Table 5.4.

SELECTION OF MEASUREMENT TYPES

For the BEAT measurement and recording system, a 5-point rating scale is used where the quality of an aspect is important, as well as presence/absence and multiple choice checklists. For each aspect, comments and observations can also be added to supplement the scoring. This helps to establish a common means of comparing all aspects within each domain and between sites to make the analysis process simpler and to produce clear comparative graphics.

Aquatic ecology part of the BEAT

This final part of the BEAT – Step 4 – is different in concept and addresses aquatic ecology. It includes a calculation of the condition of the water body as a final output. The main objective of the BEAT aquatic ecology section is to take a snapshot of water quality by assessing the condition of standing, running and marine water body(ies). The water quality assessment can be carried out using online forms and guidance notes that are freely available to be downloaded from the BEAT website (www.beat.bluehealth.tools/).

The tool starts by defining three main water body types: 1) Standing water like lakes, ponds and pools of natural origin containing fresh (i.e. non-saline), brackish or saltwater, including freshwater bodies (i.e. artificially created lakes and reservoirs, provided that they contain semi-natural aquatic communities). 2) Running waters, including springs, streams, rivers, canals and temporary watercourses. 3) Marine ecosystems defined by blue spaces that include marine habitat directly connected to oceans, seas and bays and estuaries. Marine waters may be fully saline,

Table 5.4 **Aspects of the physical domain**

<i>Aspects</i>	<i>Assessment criteria</i>
Aspect 1: Access and circulation within the site	<ul style="list-style-type: none"> • Access roads within the site • On-site car parking and its functional accessibility • Boat launching access and ramps • Footpath network and its functional accessibility (layout, desire lines, etc.) • Cycle path network and its functional accessibility (layout, desire lines, etc.) • Path construction and use of materials • Physical condition of paths (state of surfacing)
Aspect 2: Accessibility for disabled people	<ul style="list-style-type: none"> • Physical disabilities • Blind and partially sighted • Deaf and hearing impaired • Mental and learning disabilities
Aspect 3: Terrestrial recreation structures (visual quality, functionality, condition)	Presence or absence of: toilets, changing rooms, changing cubicles, cafe/restaurant, fountain, art installation, children's play area, safety equipment store, watchtower, observation deck, food and ice cream stall
Aspect 4: Water access and recreational structures (visual quality functionality, condition)	Presence or absence of: boat slipway, jetty, pier, dock edges, marinas, harbour or other retaining wall, bridge, lock, paddling pool, swimming pool
Aspect 5: Management and maintenance	<ul style="list-style-type: none"> • Maintenance of hard surfaces • Management of vegetation • Maintenance of street furniture • Site maintenance in general (litter, dog mess) • Maintenance of play areas • Maintenance of safety equipment

brackish or almost fresh. Marine habitats include those below the spring high tide limit (or below the water level in non-tidal waters) and enclosed coastal saline or brackish waters without a permanent surface connection to the sea but either with intermittent surface or sub-surface connections (as in lagoons).

The aspects selected for evaluation provide a snapshot of the ecological status of different aquatic environments. The water quality assessment processes includes monitoring, surveying, and surveillance, all based on data collection. The BEAT aquatic ecology section provides a multi-objective monitoring system based on an inventory of indicators pertaining to aspects such as 1) sedimentation or substrate types, 2) possible impacts of human activities on watercourses, 3) level of ecosystem services and 4) the quality and condition of abiotic and aquatic ecology. This assessment is achieved through a simple monitoring system using an on-site observation method.

The water quality is assessed by determining the physical, chemical and biological attributes of the water (EEA, 2012, 2018; Sivaranjani et al., 2015). The physical attributes can be defined by the shore and littoral conditions, land use and activities surrounding the water body, whereas the chemical and ecological attributes are defined through the abiotic and ecological conditions.

The water quality of a water body is directly dependent on the condition of its basin, its littoral zone or shore zone – its substrate. The substrate types and amount explain the extent of human-induced modifications near to the

water and their impact on the water body. The substrate conditions predict possible erosion or anthropogenic activities, and its quantity, quality and characteristics affect the physical, chemical and biological integrity of the aquatic ecosystem.

There are several methods available to assess the human impact (i.e. hydrological, morphological and landscape indicators) on the water quality of surface water bodies, which has been considered an external influence (Zhao et al., 2020), and many indicators have been developed to quantify the human impact on surface water quality, for example, the impact on river systems. The indicators of human impact on water bodies can reflect different types of disturbances which may negatively affect the aquatic ecological status. Changes in surface water levels might depend on climatic factors (i.e. dry periods) or human effects in the case of standing waters (Davraz et al., 2019) and obstruction of watercourses and water extraction in the case of running water, for example. The main threats that aquatic ecosystems face are due to water pollution, biological invasion of exotic species, direct human activities (such as rubbish dumping), land-use changes, the extent of the urban area and socioeconomic developments and agricultural activities that pollute water bodies through point sources (e.g. waste pipes) and non-point sources (e.g. nutrient discharge) (da Silva et al., 2020; Cooke et al., 2020).

Aquatic environments support life systems for many forms of habitat and have historically attracted human settlements and their activities. Aquatic ecosystem services and patterns in ecosystem services differ across aquatic systems. There are multiple factors such as population growth, changes in land use and agricultural and urban expansion that affect the provisioning, regulating, cultural services and human health and well-being benefits (Aznar-Sánchez et al., 2019). There are both positive and negative ecosystem services that, if used or present, could adversely affect the ecological status of a water body.

Aquatic abiotic conditions and outputs that mediate biological services have greater implications for spatial planning, management and decision-making (Teixeira et al., 2019). For example, coastal ecosystems contribute to a substantial proportion of global ecosystem services (Liquete et al., 2013), and a recent EU Member States report suggest that more than 70% of the coastal habitats are assessed as having an unfavourable status (European Union, 2017). Overall, the effect of factors on the aquatic condition such as water temperature (Meshesha et al., 2020) and the fluctuation and the level of water may be connected to the health of the littoral habitat and the whole aquatic biological community (Gownaris et al., 2018). Turbidity explains the reduced water clarity, especially in inland waters, that occurs due to the presence of suspended matter that absorbs or obstructs downwelling light and, as a result, affects phytoplankton productivity and adversely influences zooplankton production and fish feeding (Grobbelaar, 2009). Poor land management alongside water bodies leads to soil erosion, increases water pollution and siltation and degrades water quality by increasing organic matter and nutrients (Issaka & Ashraf, 2017).

Biological indicators are direct measures of the health of the fauna and flora in a water body. Biological and ecological indicators can be useful in evaluating the health status of water bodies (Parmar et al., 2016), and in the EU, biotic ones are prioritised (European Parliament 2000). This may be determined through observation of conditions, for example, domination of emergent plants; floating and floating-leaved plants; presence of invasive species; plants covered with periphyton; floating filamentous algae; dead fish on the shore; presence of waterfowl; submerged plants; presence of amphibians, fish, aquatic mammals, mussels and aquatic insects; and microbiological parameters.

Several established methods assess the ecological and aesthetic quality, and the condition of the riparian zone ascertains the health status of the water body (Saha et al., 2020). Therefore, any promotion of recreational use of coastal or inland waters or building infrastructure requires an assessment of its abiotic and biological condition and the existing ecosystem services of the aquatic environment.

According to how all these factors can be combined into a single, simple-to-administer system, the final part of the BEAT in Step 4 has been developed and tested. It is subdivided into three different aquatic types, with

Table 5.5 **Aspects for assessing the aquatic ecosystem quality for the domain of standing waters**

<i>Domain of standing fresh waters</i>	<i>Aspects</i>
Aspect 1: Substrate of the water body	<ul style="list-style-type: none"> • Substrate of shore zone (lakeside) • Substrate of littoral zone (lakeshore) (The main idea is that there are good, natural substrates and other substrate types that are indicative of moderate or high human impact.)
Aspect 2: Human impact	<ul style="list-style-type: none"> • Buildings and infrastructure • Agricultural impact • Leisure and recreation • Infrastructure for water management There are some indicators that are positive if present and others that influence a water body negatively if they are present or nearby.
Aspect 3: Ecosystem services (rapid assessment)	<ul style="list-style-type: none"> • Provisioning services • Regulating and maintaining services • Cultural services
Aspect 4: Biotic and ecological aspects	<ul style="list-style-type: none"> • Air and water temperature (for background information: if it is not possible to measure these indicators, then they are not needed for assessment) • Water level. For the ecosystem, the average water level is best, because this is natural and usually, in normal conditions, the dominant water level. A higher or lower water level (over or above average) can be an indicator of human impact or weather changes (it can be the influence of climate change, indirectly) • Hydro-physical indicators. This concerns water turbidity, bad smell of water, waste water discharge into water body and erosion • Biological indicators. These mostly concern the different types of plants (emergent, floating and floating-leaved, submerged plants), the presence of wildlife, microbiological parameters and invasive species

parallel assessment criteria and a scoring system which can be used to provide the overall answer as to the current status of the water body and its ecology. Tables 5.5–5.7 present the assessment criteria for each of the three domains.

THE TERRESTRIAL ASSESSMENT PRINCIPLES AND METHOD

As already noted, the assessment method involves a combination of objective and subjective evaluations, many linked to a set of 5-point scales. Some aspects record the presence or absence of an activity; others ask for the relative importance of an activity compared with others taking place, without the need to carry out detailed observations or counts over time. Each aspect within each domain is scored on this scale, and the output is in most cases (where there is a 5-point scale) a spidergraph showing the relative values for the domain as a whole in an easy-to-understand and easily comparable format. On the scale 5, always means that the aspect is in excellent condition, 1 means very poor condition and 3 average condition. A zero means it is not present or not applicable. For the subjective aspects, a set of questions is used to focus on the factors to include in the evaluation, and text comments can be made for all aspects. The use of two (or more) surveyors is a means of achieving more reliable scoring than if a single surveyor

Table 5.6 **Aspects for assessing the aquatic ecosystem quality for the domain of fresh running waters**

<i>Domain of running fresh waters</i>	<i>Aspects</i>
Aspect 1: Substrate of the water body	<ul style="list-style-type: none"> • Substrate of shore zone (riverside) • Substrate of littoral zone (river shore)
Aspect 2: Human impact	<ul style="list-style-type: none"> • Buildings and infrastructure • Agricultural impact • Leisure and recreation • Infrastructure for water management
Aspect 3: Ecosystem services	<ul style="list-style-type: none"> • Provisioning services • Regulating and maintaining services • Cultural services
Aspect 4: Biotic and ecological aspects	<ul style="list-style-type: none"> • Air and water temperature • Water level • Hydro-physical indicators • Biological indicators

Table 5.7 **Aspects for assessing the aquatic ecosystem quality for the domain of marine ecosystems**

<i>Domain of marine ecosystems</i>	<i>Aspects</i>
Aspect 1: Substrate of the water body	<ul style="list-style-type: none"> • Substrate of shore zone (seaside) • Substrate of littoral zone (seashore)
Aspect 2: Human impact	<ul style="list-style-type: none"> • Buildings and infrastructure • Agricultural impact • Leisure and recreation • Infrastructure for water management • Water traffic
Aspect 3: Ecosystem services	<ul style="list-style-type: none"> • Provisioning services • Regulating and maintaining services • Cultural services
Aspect 4: Biotic and ecological aspects	<ul style="list-style-type: none"> • Air and water temperature is for background information, and if there is no possibility to measure these indicators, then these are not needed for assessment • Hydro-physical indicators. This concerns water turbidity and bad smell of water • Biological. Mostly concerning the different type of plants (emergent, floating and floating-leaved, submerged plants), the presence of wildlife, livestock at the seashore, macro-algae and invasive species

carried out the assessment and is strongly recommended. Figure 5.3 shows some examples of spidergraphs generated once the data have been entered for some aspects where the 5-point scale is used. In the terrestrial assessment, there is no attempt to produce a final or average score for the site as a whole: each domain and aspect is kept separate. However, for the water ecosystem assessment, an overall score is achieved by applying the system.

WATER ECOSYSTEM ASSESSMENT PRINCIPLES AND METHOD

For ecosystem health, the assessment principle is that it is good when negative indicators are absent from the assessment site. The assessment methodology is based on scores given by the evaluator for each aspect, using a 3-point scale. The best score is always 1, which means negative indicators are absent, while the lowest score is 3, meaning

Figure 5.3

Examples of outputs of a site assessment for three aspects – safety and security, visual condition and management. These are clear and easy to understand, showing where a site does well or poorly and thus helping to identify where improvements are needed

(Source: Himansu S. Mishra)

negative indicators are present at the evaluation site (up to 200 metres distance from the water edge). The higher score therefore means a greater human impact on the water body.

After every aspect, the evaluator sums up the scores and looks for the corresponding Status Score Point on the scale. At the end of the assessment, the evaluator simply sums up the Status Score Points to find the overall status of the water body. The scale is the same for every aspect: good, moderate and poor.

The Good status indicates that the catchment area near the water body is natural or that there is no or very mild human impact.

The Moderate status indicates that near the water body, there is moderate human impact which can influence the ecosystem negatively (and therefore humans too).

The Poor status indicates that near the water body, there is high human impact which influences the ecosystem negatively.

Expert assessment, guidance and training

Since the BEAT comprises both objective and subjective aspects, it is preferable to involve at least two assessors so that independent assessments can be made and compared. Differences in opinion among the assessment team can then be discussed and final scores agreed on so as to ensure that personal biases do not unduly affect the final assessment.

To ensure a good-quality and replicable assessment, reading the guidance is necessary, followed by some practice and, ideally, training or guidance from people who have used it before. The guidance is essential for anyone using it for the first time, especially for those aspects which tend to be innately more subjective – such as visual aesthetics – where past experience or the assessor’s personal standard for beauty, assuming aesthetics or beauty to be an intrinsic physical attribute of that specific environmental setting, may need to be calibrated. It can also be assumed that local experts have knowledge on local culture, social norms and the meanings that local people attach to the place besides their in-depth knowledge of the relevant domain or topic.

It is also possible that planners might encourage communities to participate through “citizen science” and work together to collect data and to monitor sites. This method is used to collect data on urban wildlife by, for example, counting birds or other species. Indeed, some members of local communities are knowledgeable about some areas,

such as bird watchers or those engaged in recreational fishing, for example, whose expertise or tacit knowledge might be capitalised upon for the purpose of collecting good-quality data.

The training protocol involves in-office training for two hours, briefing on the detailed BEAT manual and guidance; familiarisation with the assessment items, steps and processes involved in an assessment; operational aspects of the online tool and on-site survey; safety precautions to be taken during the site survey; and illustrative examples of ways of presenting results.

Community assessment, guidance and training

For community groups, it is a good idea if someone with training helps to lead or facilitate the assessment. For Step 1, it may be helpful if the local authority or municipality can provide some of the information, while other materials may be collected or already known by community members. If for Step 2, first unbiased impressions are impossible, due to over-familiarity, then it may be useful to invite people from elsewhere to come and give a fresh opinion. Steps 3 and 4, the on-site assessments, may be done by as many people as would like to do them, and then the results can be compared, for example, in a round-table discussion. From this, an agreed-upon set of scores – or an agreement to differ – should be assembled and used for the stimulation of ideas for, for example, the regeneration of the site, perhaps using the concept of urban acupuncture (see Chapter 15) or for listing management activities which could be carried out by the community. The guidance document downloadable from the website explains what each aspect means.

The online interface for carrying out the survey is available at www.beat.bluehealth.tools/ and at <https://bluehealth2020.eu/projects/> – and anyone can use it free of charge. The on-site survey data can be entered online via a tablet or smartphone using mobile data services. A paper version of the survey questions is also available to download and use on-site, allowing the recorded data to be uploaded to the BEAT website later.

Examples of application of the BEAT

In this section, we provide some worked examples of both BEAT assessment systems: Step 3 of the terrestrial BEAT for three key domains to illustrate how the rating scales and scoring work and Step 4. Each project is briefly described, and the results are presented to illustrate the kind of result and how they are presented.

The examples here illustrate three different blue space types: for standing water, a linear urban lake in Tartu, Estonia, with a surrounding green area; for running water, a river and fluvial park and promenade in Barcelona, Spain; and for the marine environment, a coastal tidal beach and marina abutting an open park and children's play area in Plymouth, United Kingdom. The examples represent different geo-climatic regions and different cultural settings. The results presented here are divided into two separate sections 1) BEAT Step 3: terrestrial quality assessment of the blue space and 2) BEAT Step 4: aquatic environmental quality assessment of blue spaces. The terrestrial environmental quality is demonstrated for three blue space domains: physical, social and aesthetic. The aquatic environmental quality domains used for the assessment are substrate quality, human impact, ecosystem services, abiotic factors and water ecology.

Study areas

We present the three study areas first in order to give the context and different conditions, after which the assessment results will be presented as comparisons.

Standing water environment: Anne Kanal, Tartu, Estonia

Anne Kanal is located in the city of Tartu and is an artificial lake constructed during the development of the adjacent Annelinn neighbourhood – an urban extension project – during the 1970s. Today the place offers many outdoor and water-based recreation opportunities for the community living nearby as well for the whole city of Tartu. The site is very accessible by public transport, foot, bicycle and car. It is well connected to the surrounding neighbourhood and city centre shopping district and very well used by large numbers of locals and tourists throughout the year. The place constitutes three distinct geographical units and activity zones. 1) The eastern and northern canal-side recreational zone with a beach, beach facilities and amenities, parking, walking paths, a children's play area, ball game courts and water access infrastructure. 2) The western and southern zone is a strip of land lying between Anne Kanal and the River Emajõgi (to which it is connected) with a walking and cycling path, a vegetated riparian edge and overgrown reed beds, seating spaces and picnic shelters. 3) The lake itself with shallow and deep sections. Figure 5.4 shows the location and setting of Anne Kanal with the three zones.

The water quality of the lake is sufficient for bathing, and it is used for many water-based activities, such as swimming and water sports in summer, and when frozen, it is used for ice-dipping and ice fishing in winter. The area surrounding the lake is extensively used for running, walking, cycling, playing ball games, informal play, children's play,

Figure 5.4a and b

a) Location of Anne Kanal in the city of Tartu; b) a close-up of the surveyed area showing the three main zones

(Source: © OpenStreetMap CC-BY-SA)

relaxing and fishing and for skiing, skating and other winter activities. Compared to the northern and eastern parts of the lake, the western and southern parts are kept more natural, with dense vegetation patches and a wide reed- and willow-dominated riparian edge. Water accessibility and visibility are higher on the northern and eastern parts of the lake compared to the western and southern sections. Despite the rich natural setting, the site is very urban, with a dominating visual and olfactory experience of urban features and functions.

The water body sedimentation or substrate is mostly sandy and free of mud or the presence of technosol. The major adverse human impacts that can be found are the nearby presence of housing, buildings, maintained landscape, road and parking areas, concrete structures and the presence of rubbish and litter within the site and water. The ecosystem services of the aquatic environment at Anne Kanal can be rated as moderate based on the low level of use in the reed bed areas, a large quantity of water exchange with the river, the presence of some protected species and the water quality being sufficient for bathing and fishing. The majority of the indicators suggest that negative ecosystem services are absent, except for the existence of infrastructure and the presence of recreation facilities. In terms of its hydrological and physical condition, Anne Kanal water is not particularly turbid and does not smell bad or have visible erosion around the water body. Poor biological and ecological indicators were not found to be present, such as invasive species, floating algae or dead fish. The health of water ecology was scored as moderate due to many indicators not being directly present, except for amphibians. Figure 5.5a–d shows some views of Anne Kanal identifying the different parts.

Figure 5.5a–d

Anne Kanal, Tartu, a) Shows the running and cycle path along the edge between the housing public road and lake; b) is the section on either side with the reed and willows along the lake edge; c) shows the swimming facilities; d) is the beach area with play equipment. The photos were taken in October 2019 on a weekday, which is why the site is empty

(Source: Himansu S. Mishra)

Northern Besós Fluvial Park, Barcelona

The case study focuses on a canalised stretch of the Besós River, located in the urban context of the Montcada i Reixach municipality, part of the Barcelona metropolitan area. Montcada is a relatively poor municipality which was severely affected by flooding in the 1960s, as a result of which it was canalised and regulated, leading to its present engineered configuration with artificial sloping banks on both sides and a broad bottom to the corridor which allows flood waters to build up without overflowing into nearby areas. The site symbolises the link between the river stretch near Montcada due to its geomorphological configuration. The site is asymmetrical to the river axis. To one side is the urban area, formed of low-cost housing in five- to seven-storey blocks built originally for the workers of the nearby Valentine factory. The other side maintains a somewhat more natural aspect connected to the marine natural park at the river mouth. Until the 1960s, the Besós River was a dynamic, braided river with a bed of shifting gravel deposits and poor water quality due to pollution from industries sited along the upper stretches. The site is now a fluvial park with improved public accessibility, which was developed as a community intervention project. The river is now protected by Natura 2000 and by the ACA (Agència Catalana de l'Aigua), which manages all uses and activities along it. The stretch used for demonstrating the BEAT can be divided into two distinct zones: 1) an upper zone above the retaining embankments with a pathway, urban park, parking and informal and formal play areas and 2) a lower fluvial park within the river basin, containing different biotopes of dense vegetation, grass, a concrete and gravel pathway, concrete steps and ramps which were constructed to allow access into and out of the lower park. The water body is now reduced to a regulated channel managed by a system of dams, with defined grass and riparian vegetated areas on both sides. The water quality is still considered poor, and the place does not offer any water-based activities. The lower fluvial park is primarily used for walking, cycling, dog walking and playing with dogs. The upper zone offers excellent views of the lower fluvial park and the surrounding areas. There is a flood warning system in place in case a flash flood occurs, to allow people in the effluvial park time to escape. Figure 5.6a and b shows the location of the stretch which was assessed within its wider context.

The sedimentation type within the fluvial park is a mix of clay and gravel, suggesting a good substrate type. In terms of human impact on water quality, most of the activities can be found within a distance range of 200 to 1000 m; therefore, the impact of human activities can be considered low according to the criteria. Major human impact concerns spotted during the assessment were the presence of rubbish and pollution, wastewater discharge and the modified river bed. In terms of positive ecosystem services, endangered species have been found at the site and the nearby protected area. Some of the negative ecosystem services identified at the site include the artificial modification of the water body, non-point and point source pollution, wastewater discharge (from a nearby sewage works), construction and obstruction of the watercourse. In terms of hydrological and physical indicators, there were unpleasant smells and visible erosion observed there. Some of the negative biological and ecological indicators suggest poor health of the watercourse through the presence of invasive species. Positive indicators observed at the site include the presence of amphibians, fish, aquatic mammals and insects. Figure 5.7a–d shows some views of the Besós fluvial park.

Teats Hill, Plymouth

Teats Hill in Plymouth, United Kingdom, a waterfront project jointly funded by Plymouth's Active Neighbourhood Project (Plymouth City Council) and the BlueHealth project, was chosen for BEAT testing. As an urban waterfront, Teats Hill has been a long-neglected public space. It is surrounded by institutional and residential land use, exposed to the sea on the southern side, and the site lacked quality and attractiveness. As an experimental project within BlueHealth, it received substantial improvement, before which, and as part of the planning, it was assessed. It is a historically and environmentally rich site situated opposite the famous Mayflower Steps and host to abundant marine wildlife. The site can be divided into four geographical and activity zones: 1) the park with seating facilities, access

Figure 5.6a and b

a) Location of the Besós River within the Barcelona metropolitan area; b) the assessed stretch within its local context

(Source: © OpenStreetMap CC-BY-SA)

path and slip road; 2) children's play area, with play equipment, ball court, green informal play areas; 3) the beach, with an old disused boat slipway, gravel beach and shingle; and 4) the water, with the marina. The access to the slipway was blocked with big stones, and aspects of the site had fallen into disrepair, such as the damaged slipway, overgrown vegetation, a degraded beach, excessive seaweed growth and a park environment mainly used by the local community for dog walking and incidental visits. The aquatic space was less used for water-based activities, and the existing marina was the main source of water pollution. The beach collects a huge amount of urban litter and is subject to high tidal variability. The beach can only be accessed via the slip road, as the length of the waterfront has an rocky cliff formation. The site provides excellent views of the old town, marina and bay. Figure 5.8a and b shows the location of Teats Hill within the city of Plymouth and its local context.

The marine substrates were found to be a combination of rock and gravel, which is considered good. Negative human impacts were identified as the presence of buildings, housing, maintained grassland, parking areas, sedimentation, beach activities, boating, drainage disposal, artificial shore protection, artificial objects in the water, rubbish, pollution and water traffic. In terms of positive ecosystem services, the site provides many as a result of the presence of the marine protection zone, natural sedimentation, tidal activity and the water being

Figure 5.7a–d

Views of the Northern Besós Fluvial Park, Barcelona, a) Shows the wide valley park with the river running within, occupying a narrow proportion of the bottom; b) shows the profile of the engineered slopes with a recently added access ramp and steps allowing use of the fluvial park below; c) is a closer view of the river showing the character of the riparian edges, while d) shows the upper linear park on the top of the embanked valley sides in the residential sector (Source: Himansu S. Mishra)

suitable for swimming. Negative ecosystem services were found present at the site, including the presence of concrete structures, boating activities and point and diffuse sources of pollution and wastewater discharge points. The hydrological and physical condition of the site was found to be good. In terms of negative biological and ecological indicators, invasive species were present at the site, and the majority of positive indicators were present, except for a few, such as the absence of amphibians and aquatic mammals (seals visit but were not present at the time of assessment) that suggested good health of the water ecology. Figure 5.9a–d shows some views of Teats Hill.

Figure 5.8a and b

a) The site location within the Plymouth urban area; b) the site in its local context

(Source: © OpenStreetMap CC-BY-SA)

Figure 5.9a-d

Teats Hill, Plymouth, a) an overview of the site showing the land-water interface with the shore slipway and cliffs; b) the grassy park with picnic tables and trees; c) the slip road leading down to the old slipway, now used for parking; d) the old slipway itself

(Source: Himansu S. Mishra)

Figure 5.10

Assessment results of aspects of the physical domain of terrestrial blue spaces for the three demonstration sites
 (Source: Himansu S. Mishra)

Example of results of Step 3: assessment results of the aspects of terrestrial blue space of three domains (physical, social, aesthetic) for each site

The examples here are for the three different water body types presented in the example projects. For standing water, it is Anne Kanal in Tartu; for running water, it is the Besós River in Barcelona; and for the marine environment, it is Teats Hill in Plymouth. Spidergrams presented in Figures 5.10–5.12 show the quality and condition of blue space attributes for different aspects. The aspects are clustered according to the different blue space domains and can be compared by looking at them side by side. The results suggest that even though there are differences in the quality and condition of blue space attributes within each blue space type, there are also similarities that can be observed across blue space types within the three domains: the physical (Figure 5.10), social (Figure 5.11) and aesthetic (Figure 5.12).

Figure 5.11
Assessment results of aspects of the social domain of terrestrial blue spaces for the three demonstration sites
 (Source: Himansu S. Mishra)

Figure 5.12
Assessment results of aspects of the aesthetic domain of terrestrial blue spaces for the three demonstration sites
 (Source: Himansu S. Mishra)

Table 5.8 **Results of the assessments of the standing and running water and marine environment demonstration sites**

		<i>Standing water</i>		<i>Fresh running water</i>		<i>Marine environment</i>	
		<i>Anne Kanal, Tartu</i>		<i>Northern Besòs Fluvial Park, Barcelona</i>		<i>Teats Hill, Plymouth</i>	
Aspect	status score	Points		Points		Points	
points standing							
Substrate	Good	1	2	1	2	1	2
	Moderate	2	4	2	4	2	4
	Poor	3	6	3	6	3	6

Example of results of Step 4: assessment results for three types of water environments

The results for the BEAT Step 4 assessment of aquatic environmental quality of each demonstration site are presented in Table 5.2. The results show a variety of different scores for the input variables and the final results at the time the assessments were made. Of the examples, all sites turned out to be moderate in quality. This is to be expected when all the water bodies are in urban settings with many man-made impacts in their immediate vicinity.

Conclusions

This chapter has presented the need for, the rationale behind and the development and application of a new tool for assessing blue spaces. It has been extensively tested in numerous locations around Europe and beyond, and we have received feedback and reviews from many people. This has helped us to refine the tool and its user-friendliness, as well as helping us ensure that the guidance is comprehensible for users of different types. It has proved versatile and can be used by both professionals and communities.

		<i>Standing water</i>		<i>Fresh running water</i>		<i>Marine environment</i>	
		<i>Anne Kanal, Tartu</i>		<i>Northern Besòs Fluvial Park, Barcelona</i>		<i>Teats Hill, Plymouth</i>	
Human impact	Good	1	29–47	1	30–50	1	31–52
	Moderate	2	48–67	2	51–70	2	53–74
	Poor	3	68–87	3	71–90	3	75–93
Ecosystem services	Good	1	16–26	1	16–26	1	21–35
	Moderate	2	27–37	2	27–37	2	36–50
	Poor	3	38–48	3	38–48	3	51–63
Biological and ecological aspects	Good	1	19–31	1	10–16	1	12–19
	Moderate	2	32–44	2	17–23	2	20–28
	Poor	3	45–57	3	24–30	3	29–36
Sum of Score points and status		7	<i>Moderate</i>	7	<i>Moderate</i>	8	<i>Moderate</i>

Sum of score points present the ecological status of water body (i.e. 4–5 points for Good status, 6–9 points for Moderate status and 10–12 points for Poor status)

References

- Aznar-Sánchez, J. A., Velasco-Muñoz, J. F., Belmonte-Ureña, L. J., & Manzano-Agugliaro, F. (2019). The worldwide research trends on water ecosystem services. *Ecological Indicators*, 99, 310–323.
- Bakker, I., van der Voordt, T., Vink, P., & de Boon, J. (2014). Pleasure, arousal, dominance: Mehrabian and Russell revisited. In *Current psychology*. New York: Springer Science+Business Media.
- Berto, R. (2014). The role of nature in coping with psycho-physiological stress: A literature review on restorativeness. *Behavioral Science*, 4, 394–409.
- Cooke, S. J., Bergman, J. N., Nyboer, E. A., Reid, A. J., Gallagher, A. J., Hammerschlag, N., . . . Vermaire, J. C. (2020). Overcoming the concrete conquest of aquatic ecosystems. *Biological Conservation*, 247, 108589.
- da Silva, F. L., Stefani, M. S., Smith, W., Schiavone, D. C., da Cunha-Santino, M. B., & Bianchini Jr, I. (2020). An applied ecological approach for the assessment of anthropogenic disturbances in urban wetlands and the contributor river. *Ecological Complexity*, 43, 100852.
- Davraz, A., Sener, E., & Sener, S. (2019). Evaluation of climate and human effects on the hydrology and water quality of Burdur Lake, Turkey. *Journal of African Earth Sciences*, 158, 103569.
- European Union. (2017). *Life and coastal habitats*. Luxembourg: European Commission Environment Directorate General, European Union.
- European waters – Assessment of status and pressures. (2012). EEA report. No 8/2012. European Environmental Agency. 100 pp.
- European waters. Assessment of status and pressures. (2018). EEA report. No 7/2018. European Environmental Agency. 90 pp.
- Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Kahn Jr, P. H., Lawler, J. J., . . . Wood, S. A. (2017). Nature contact and human health: A research agenda. *Environmental Health Perspectives*, 125(7).
- Gibson, J. J. (1979). *The theory of affordances. The ecological approach to visual perception*. Boston: Houghton Mifflin.
- Gownaris, N. J., Rountos, K. J., Kaufman, L., Kolding, J., Lwiza, K. M., & Pikitch, E. K. (2018). Water level fluctuations and the ecosystem functioning of lakes. *Journal of Great Lakes Research*, 44(6), 1154–1163.
- Grobbelaar, J. U. (2009). Turbidity. In G. Likens, M. E. Benbow, T. M. Burton, E. Van Donk, J. A. Downing, & R. D. Gulati (Eds.), *Encyclopedia of inland waters*. Amsterdam: Elsevier BV.
- Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health*, 35, 207–228.
- Hartson, R. (2003). Cognitive, physical, sensory, and functional affordances in interaction design. *Behaviour & Information Technology*, 22(5), 315–338.
- Issaka, S., & Ashraf, M. A. (2017). Impact of soil erosion and degradation on water quality: A review. *Geology, Ecology, and Landscapes*, 1(1), 1–11.
- Korpela, K. M., Ylén, M., Tyrväinen, L., & Silvennoinen, H. (2008). Determinants of restorative experiences in everyday favourite places. *Health & Place*, 14, 636–652.
- Liquete, C., Zulian, G., Delgado, I., Stips, A., & Maes, J. (2013). Assessment of coastal protection as an ecosystem service in Europe. *Ecological Indicators*, 30, 205–217.
- Meshesha, T. W., Wang, J., & Melaku, N. D. (2020). Modelling spatiotemporal patterns of water quality and its impacts on aquatic ecosystem in the cold climate region of Alberta, Canada. *Journal of Hydrology*, 124952.
- Mishra, H. S., Bell, S., Vassiljev, P., Kuhlmann, F., Niin, G., & Grellier, J. 2020. The development of a tool for assessing the environmental qualities of urban blue spaces. *Urban Forestry & Urban Greening*, 49.
- Parmar, T. K., Rawtani, D., & Agrawal, Y. K. (2016). Bioindicators: The natural indicator of environmental pollution. *Frontiers in Life Science*, 9(2), 110–118.

- Saha, D., Das, D., Dasgupta, R., & Patel, P. P. (2020). Application of ecological and aesthetic parameters for riparian quality assessment of a small tropical river in eastern India. *Ecological Indicators*, 117, 106627.
- Sivaranjani, S., Rakshit, A., & Singh, S. (2015). Water quality assessment with water quality indices. *International Journal of Bioresource Science*, 2(2), 85–94.
- Stokols, D. (2003). The ecology of human strengths. In Lisa G. Aspinwall & Ursula M. Staudinger (Eds.), *A psychology of human strengths: Fundamental questions and future directions for a positive psychology*. Washington, DC and London: American Psychological Association.
- Teixeira, H., Lillebø, A. I., Culhane, F., Robinson, L., Trauner, D., Borgwardt, F., . . . O'Higgins, T. (2019). Linking biodiversity to ecosystem services supply: Patterns across aquatic ecosystems. *Science of the Total Environment*, 657, 517–534.
- USDA. (2018). *Urban nature for human health and well-being*, United States department of agriculture. FS-1096. Washington, DC.
- Zhao, Y., Zeng, L., Wei, Y., Liu, J., Deng, J., Deng, Q., . . . Li, J. (2020). An indicator system for assessing the impact of human activities on river structure. *Journal of Hydrology*, 582, 124547.

Appendix 1 Tools used to inform the development of the BEAT

	Tool name	Brief overview
1	Place Standard	<p>About the tool: Place Standard, developed by the Scottish government, is an assessment tool developed to evaluate the quality of the place that is well established, undergoing change or still being planned and help evaluators to identify their priorities among interventions to improve the place.</p> <p>Year: 2015</p> <p>Web reference: www.placestandard.scot/#/home</p>
2	Green space strategies: a good practice guide	<p>About the tool: Developed by the UK Commission on Architecture and the Built Environment (CABE), the tool was designed for public open or green space auditing and aimed to provide more of a snapshot of each space than a detailed analysis.</p> <p>Year: 2004</p> <p>Web reference: http://webarchive.nationalarchives.gov.uk/20110118095356/http://www.cabe.org.uk/files/green-space-strategies.pdf</p>
3	Tools for evaluating impacts of Woodlands In and Around Towns (WIAT) interventions	<p>About the tool: This evaluation tool focuses on a community-level evaluation of interventions aimed at improving woodlands to improve people's quality of life.</p> <p>Year: 2010</p> <p>Web reference: www.openspace.eca.ed.ac.uk/research-projects/woods-in-and-around-towns/</p>
4	Assessing the Sustainability of Public Space (ASPiS)	<p>About the tool: The ASPiS Star Rating Tool originated in a project funded through the Lifelong Learning Programme of the EU to stimulate dialogue between urban citizens and professional architects and planners, with a focus on the sustainability of public open space.</p> <p>Year: 2010</p> <p>Web reference: www.aspis-learn.eu/index.php</p>

	Tool name	Brief overview
5	Quality of Public Open Space Tool (POST)	<p>About the tool: The Quality of Public Open Space Tool (POST) was developed by the University of Western Australia for conducting environmental audits of public open spaces. Year: 2004 Web reference: www.see.uwa.edu.au/research/cbeh/projects/post Reference: Broomhall M, Giles-Corti B, Lange A (2004). Quality of Public Open Space Tool (POST). Perth, Western Australia: School of Population Health, The University of Western Australia.</p>
6	Green Flag Award Scheme	<p>About the tool: The Green Flag Award scheme is the benchmark national standard for parks and green spaces in England and Wales. It aims towards raising standards of green spaces. Year: Founded in 1996, updated 2009 Web reference: www.greenflagaward.org/about-us/about-green-flag-award/guidance-manual/</p>
7	Blue Flag Award programme	<p>About the tool: The Blue Flag programme for beaches and marinas is run by the international, non-governmental, non-profit organisation the Foundation for Environmental Education (FEE). It promotes sustainable development in freshwater and marine areas and aims to achieve high standards in the four categories water quality, environmental management, environmental education and safety. Year: 1985 Web reference: www.blueflag.global/criteria/</p>
8	Landscape evaluation and quality surveys	<p>About the tool: Developed by the Royal Geographical Society, this tool aims to assess people's reactions to and opinion about a particular development, different management strategies, quality of amenity, quality and suitability of services and perception of a place. Year: 2015 Web reference: www.rgs.org/OurWork/Schools/Fieldwork+and+local+learning/Fieldwork+techniques/Human+impact+studies.htm</p>
9	Neighbourhood green space quality assessment tool	<p>About the tool: This tool is published in the journal <i>Landscape and Urban Planning</i>. It was developed in Stoke-on-Trent, United Kingdom, for looking at green spaces at the neighbourhood level. Year: 2012 Reference: Gidlow, C.J., Ellis, N.J., Bostock, S., (2012), Development of the Neighbourhood Green Space Tool (NGST), <i>Landscape and Urban Planning</i>, 106, 347–358.</p>
10	Urban stream condition	<p>About the tool: This tool was presented in a conference paper as an outcome of research in Brazil. It is designed to provide a rapid evaluation method to assess the condition of a stream by identifying a set of indicators and parameters that may offer appropriate initiative and investment direction for restoration, conservation and protection of urban rivers and streams. Year: 2011 Reference: Pompêo, C. A., Rigotti, J. A. and Freitas Filho, M.D., (2011), Urban Stream Condition Assessment, 12nd International Conference on Urban Drainage, Porto Alegre/Brazil, 10–15 September 2011.</p>

	Tool name	Brief overview
11	Model for assessment of public space quality in town centres	<p>About the tool: This tool was developed by Polish researchers and presented in the journal <i>European Spatial Research and Policy</i>. It is a model for assessment of the quality of public space in town centres based on studies of methods already used in Poland and abroad and constructs a set of criteria for assessment methods.</p> <p>Year: 2016 Reference: Wojnarowska, A., (2016), Model for assessment of public space quality in town centres, <i>European Spatial Research and Policy</i>, 23(1).</p>
12	NATLAND: Evaluation of public spaces in urban areas	<p>About the tool: This tool was developed as part of a master thesis and was itself derived from reviewing other methods. It was applied to the city of New Westminster, British Columbia, Canada.</p> <p>Year: 2007 Reference: Natland, J. (2007), Urban by Design: An Evaluation of Public Spaces in Downtown New Westminster, Simon Fraser University.</p>
13	What Makes a Successful Place?	<p>About the tool: The Project for Public Spaces (PPS) is a non-profit planning, design and educational organisation and developed a public space assessment tool after evaluating thousands of public spaces around the world.</p> <p>Year: 2009 Web reference: www.pps.org/reference/grplacefeat/</p>
14	Local Action Toolkit: Ecosystem benefit assessment in urban water environments	<p>About the tool: The Urban Catchment Partnerships, working with local communities, aims to enhance the value of natural capital in towns, cities and urban spaces. The toolkit was produced by the Westcountry Rivers Trust with funding from DEFRA and the Environment Agency to provide communities with evidence on the impacts, costs and benefits of natural capital/green infrastructure along with the methods to build consensus, facilitate local decision-making and secure funding for opportunities.</p> <p>Year: 2015 Web reference: http://urbanwater-eco.services/project/urban-practitioners-toolbox/</p>
15	Assessing social impacts in urban waterfront regeneration	<p>About the tool: This tool, presented in the journal <i>Environmental Impact Assessment Review</i>, was developed by researchers in Finland for the purpose of conducting social impact assessments of waterfront developments.</p> <p>Year: 2006 Reference: Sairinen, R., Kumpulainen, S., (2006), Assessing social impacts in urban waterfront regeneration, <i>Environmental Impact Assessment Review</i>, 26, 120–135.</p>
16	SpaceShaper	<p>About the tool: Developed by the Commission for Architecture and the Built Environment (CABE), SpaceShaper provides a practical toolkit to measure the quality of a public space before investing time and money in improving it.</p> <p>Year: 2007 Web reference: www.designcouncil.org.uk/resources/guide/spaceshaper-users-guide</p>

	Tool name	Brief overview
17	Facebook 4 Urban Facelifts	<p>About the tool: This tool was presented by researchers from Italy in the journal <i>International Journal of Global Environmental Issues</i>. It was developed around a case study and aims to assess the attractiveness of urban waterfronts.</p> <p>Year: 2015</p> <p>Reference: Gravagnuolo, A., Biancamano, P.F., Angrisano, M. and Cancelliere, A. (2015) 'Assessment of waterfront attractiveness in port cities – Facebook 4 Urban Facelifts', <i>Int. J. Global Environmental Issues</i>, Vol. 14, Nos. 1/2, pp. 56–88.</p>