Sites for Sustainable Development:

Realizing the Potential of UNESCO Designated Sites to Advance Agenda 2030

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Supplementary Information

This document contains supplementary information for the report: Sites for Sustainable Development: Realizing the Potential of UNESCO Designated Sites to Advance Agenda 2030.

- The main report can be accessed here: https://unesco.org.uk/sites_for_sustainable_development_main_report
- The executive summary (English) is available here: https://unesco.org.uk/sites_for_sustainable_development_executive_summary_English
- The executive summary (French) is available here: https://unesco.org.uk/sites_for_sustainable_development_executive_summary_French

Authors (in alphabetical order):
Tim Carter, Niaxo, London, UK
Eleanor R. Haine, Canadian Commission for UNESCO, Ottawa, Canada
Alexander J. Kent, Canterbury Christ Church University, Canterbury, UK
Matthew Rabagliati, UK National Commission for UNESCO, London, UK

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Canadian Commission for UNESCO
150 Elgin Street
PO Box 1047
Ottawa ON K1P 5V8
Canada

ccunesco@ccunesco.ca
+1-613-566-4414

and

UK National Commission for UNESCO
Suite 98
3 Whitehall Court,
London SW1A 2EL
UK

info@unesco.org.uk
+44(0) 207 766 3492

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Section 1: Skell Valley Landscape Project

The tables below show how the Skell Valley Action Plan brings multiple stakeholders in the Fountains Abbey and Studley Royal UNESCO World Heritage Site (UK) together to address interconnected sustainable development challenges: well-being, inequality and decent work (table 1) and climate change (table 2).

The project has been re-structured into steps to show how the five requirements identified in this report could potentially work in practice. The steps below correspond to the key steps in tables 1 and 2 and also provide a guide to UNESCO designated site coordinators and management teams looking at adopting similar approaches.

Key to steps

Step 1

Identify challenges

Through various studies, desk-based research, consultations and questionnaires etc., the designated site management team, in partnership with its existing/new stakeholders and communities, identify the various threats/challenges the site faces. As we have done in this report, designated sites could use the World Heritage third reporting cycle comprising of 13 categories of threat and 169 specific threats to establish a baseline.

Step 2

Identify Relevant SDGs

Using the 17 SDGs as a framework, designated site managers/coordinators work with communities and stakeholders to identify the social, environmental, economic, and cultural impacts of the threats they face. For example, mitigating flooding and flood damage is directly related to SDG13, but also directly impacts local businesses (SDG11), community well-being (SDG3) and farming methods (SDG12).

Step 3

Develop Site-Specific Vision Statement

The designated site management team, working with its key partners, then establishes an agreed vision for the UNESCO designated site and its stakeholders and rights holders to mitigate/adapt/overcome these various social, economic, environmental, and cultural threats. The SDGs can be useful a tool to help coordinate stakeholder action across a designation and establish a shared positive vision to build broad support.

Step 4

Stakeholder identification

The designated site management team then identifies the various stakeholders and rights holders needed to holistically address these interconnected threats and fulfil the vision. This will require an inclusive approach and may need to go beyond stakeholders in the designation management/steering committees.

Step 5

Design Responsive Projects

Designated site management teams, their stakeholders and rights holders, then co-design inclusive projects to address the impacts of the threats in line with the vision and SDGs. For example, to address flooding, while one project may directly work with farmers and environment agencies to build flood management (and contribute to SDG13), another may work to educate local communities and businesses about flooding and how they can address it (SDG11).

Table 1: Integrated approach for addressing social challenges

'Sites for Sustainable Development' Model: Proposed approach for designated site management teams

Step 1 – Identify challenges / Step 2 – Identify SDGs

Step 1: Identify challenges	Step 2: Identify SDGs
Barriers to people accessing nature and heritage Certain local communities are less likely to use the natural environment for recreation than others. Common barriers preventing use include money, access to travel, a lack of information and confidence about going to the countryside and what there will be to do.	3 Good health and well-being 10 Reduced inequalities 11 Sustainable cities and communities
Neglect and loss of heritage There is a lack of recognition, understanding and interpretation of heritage among local communities. For example, the poor condition of buildings and nature across the designated site means the risk of losing part of the site's heritage and history forever.	4 Quality education 11 Sustainable cities and communities 13 Climate action 15 Life on land
COVID-19 pandemic The pandemic has had a huge impact on physical and mental health and well-being across communities in the World Heritage Site, and caused a local economic recession. The pandemic also saw a greater desire for local communities to access green spaces across the site.	3 Good health and well-being 8 Decent work and economic growth 11 Sustainable cities and communities 12 Responsible consumption and production 15 Life on land

Step 3 – Develop Site-Specific Vision Statement

Empowering people

- Empower a wide range of people to learn new skills and lead conservation work in their local areas
- Work in partnership to improve and diversify volunteering experiences
- Bring the benefits of nature to more built-up areas and create better spaces for people and wildlife
- Encourage people to learn how to recognize wildlife along the Skell River to inspire positive action

Step 4 – Stakeholder identification

Environmental
- Nidderdale Area of Outstanding Natural Beauty
- Yorkshire Dales Rivers Trust Natural England
- Environment Agency
- Woodland Trust
- Forestry Commission

Projects the stakeholders are involved in: Skell Valley Task Force, Watery Wildlife, Digging Deep in the Archives, Volunteering City of Ripon, Nature on Your Doorstop

Heritage groups
- Ripon Museums Trust
- West Yorkshire Archives
- Nidderdale Parks & Gardens Research Group

Projects the stakeholders are involved in: Digging Deep in the Archives, Volunteering City of Ripon

Schools and learning
- Local primary schools
- Universities and colleges
- Young farmers groups

Projects the stakeholders are involved in: Skell Valley Task Force, Watery Wildlife, Digging Deep in the Archives, Volunteering City of Ripon, Nature on Your Doorstop

Volunteering
- Ripon YMCA
- Connecting Ripon
- Ripon Rotary Club
- Ripon Walled Garden
- Ripon Young Carers
- Dementia Forward
- Ripon Disability Forum

Projects the stakeholders are involved in: Skell Valley Task Force, Watery Wildlife

Landowners
- National Trust
- Local farmers
- Local landowners
- Harrogate Borough Council
- Local parish councils

Projects the stakeholders are involved in: Skell Valley Task Force, Nature on Your Doorstop

Step 5 – Design responsive projects

Skell Valley Task Force
Create a Skell Valley Task Force made up of volunteers trained to take an active role in conserving and improving the area by delivering practical conservation works along the length of the river.

Watery Wildlife
Engage with local school students, families and community groups about the wildlife living along the river and how we can all help look after them and their habitats to support them.

Digging Deep in the Archives
Train people in archive research and oral history to collect information about the history and natural heritage of the valley.

Volunteering City of Ripon
Work with local volunteer and community organizations in the Ripon area to foster a shared approach to recruiting, training, managing and supporting volunteers.

Nature on Your Doorstop
Empower communities to create green spaces for nature near to where they live by providing "get started" seed packs and gardening tool libraries. Make more spaces wildlife friendly and accessible.

Project key

- Skell Valley Task Force
- Watery Wildlife
- Digging Deep in the Archives
- Volunteering City of Ripon
- Nature on Your Doorstop

Table 2: Integrated approaches to addressing climate change

'Sites for Sustainable Development' Model: Proposed approach for designated site management teams

Step 1 **Identify challenges**	Step 2 **Identify SDGs**	Step 3 **Develop Site-Specific Vision Statement**	Step 4 **Stakeholder identification**	Step 5 **Design responsive projects**
Flooding Repeated flooding across the World Heritage Site puts Fountains Abbey ruins and Studley Royal Water Garden at risk.	3 GOOD HEALTH AND WELL-BEING 13 CLIMATE ACTION 15 LIFE ON LAND	**Make the Landscape Resilient** Mitigate and adapt to the harmful impacts of climate change in the UNESCO World Heritage site and surrounding areas. Ensure the area plays its part in a green recovery following the COVID-19 pandemic to make the landscape, its people and the local economy more resilient.	**Environmental** • Natural England • Nidderdale Area of Outstanding Natural Beauty • Forestry Commission **Projects the stakeholders are involved in:** **Landowners** • National Trust • Local farmers • Local landowners **Projects the stakeholders are involved in:** **Businesses** • Yorkshire, North Yorkshire and the East Riding Local Enterprise Partnership **Projects the stakeholders are involved in:**	**Healthy Land, Healthy River** Deliver natural flood management measures to slow the flow of water into the Skell River and reduce the impacts of flooding on heritage sites and people living downstream. **Tourism** Boost the local economy to generate activity that encourages people to stay longer, spend more and see Ripon and the Skell Valley. **Enterprising Landscape** Develop new models to promote and sustain landscapes, people and the local economy by making connections between businesses downstream and farmers upstream. **Woodland promotion** Plant new woodland and support better management to increase resilience to climate change-related threats from pests, diseases and non-native species.
Flood Damage River sediment deposited at Grantley Hall, Studley Royal and Eavestone threatens sustainability, spoils visitor enjoyment and puts the properties' heritage at risk. Furthermore, businesses and homes in Ripon are at risk of flood damage.	8 DECENT WORK AND ECONOMIC GROWTH 11 SUSTAINABLE CITIES AND COMMUNITIES 12 RESPONSIBLE CONSUMPTION AND PRODUCTION			
Invasive non-native species Commercial species of trees are planted among unrecorded veteran trees in ancient and native woodlands making them vulnerable to disease.	3 GOOD HEALTH AND WELL-BEING 15 LIFE ON LAND			
Drought Drought and low water levels impact on nature and heritage.	15 LIFE ON LAND			

Project key

Healthy Land, Healthy River

Tourism

Enterprising Landscape

Woodland promotion

Section 2: Survey data collection and analysis

Data collection

In September 2020, the National Commissions for UNESCO of Canada and the UK invited their UNESCO World Heritage Sites, biosphere reserves and global geoparks to take part in a survey to determine their capacities to be "sites for sustainable development". The survey was made available in English and French and administered using SurveyMonkey (see this link for the survey text).

The survey contained three sections of questions designed to gather:

- background information about the UNESCO designation
- information about factors that currently threaten or negatively impact the designation
- information about each site's use of geospatial data

Section 1 of the survey gathered information that could help in the interpretation of the sites' capacities to manage the threats they identified in Section 2.

Section 2 contained a list of 82 *specific threats* grouped under 13 overall *categories of threat* (such as buildings and development, climate change and severe weather events, or social and cultural uses of heritage). The list of threats is the same one adopted by the World Heritage Committee for periodic reporting. Sites were asked to identify and rank the top three *specific threats* they believed would pose the most significant challenges to their designation over the next 10 years, and indicate the dimensions and scales of the threats (Table 3).

Table 3. Dimensions and scales of threats

Dimension	Definition	Scale (low to high)			
Spatial scale	Area of designation affected by the threat	Restricted	Localized	Extensive	Widespread
Temporal scale	Occurrence of the threat in designation	One-off/rare	Intermittent/ sporadic	Frequent	Ongoing
Impact	Effect on the designation's attributes/functions	Insignificant	Minor	Significant	Catastrophic
Management response	Capacity of management to respond	No capacity and/or resources	Low capacity	Medium capacity	High capacity
Trend	Development over the last 6 years in designation	Decreasing	Static	Increasing	

Sections 3 and 4 of the survey were designed to gather additional information that could help in the interpretation of the sites' capacities to manage the threats they identified in Section 2 and contained questions about how sites use geospatial data.

Data analysis

Analysis of threats

The survey asked participants to identify *specific threats* and indicate their severity and trend. Only *specific threats* identified by sites were assigned scores. The top three *specific threats* identified by each site were transformed by applying weightings of 4, 3 or 2 according to the respective rankings of first, second, or third. All other *specific threats* identified by each designation each scored 1. The mean for each *specific threat* was calculated according to country and designation type, and separately by designation type or country. The use of the mean allowed for comparisons to be drawn between designation types, given the different numbers of responses by designation type (for example, 23 World Heritage Sites responded versus six global geoparks and 12 biosphere reserves). This provided an overview of the relative severity of threats across the dataset.

Cluster analysis

We used the multivariate data produced from Section 2 of the survey data to identify groups of designated sites facing similar combinations of threats by applying a cluster analysis. As a technique for analyzing multivariate data, cluster analysis uses mathematical measures of numeric "distance" to see how easily each case can be "fused" with others to create clusters, and whether these clusters can, in turn, be distinguished as groups.[1] By classifying cases according to their variations among a set of variables, it is possible to minimize within-group variation and maximize between-group variation.

Although some methods of cluster analysis begin with an *a priori* decision to form a set number of groups, we applied an agglomerative or hierarchical cluster analysis technique. This technique explores the data to determine the number of groups. The method begins with n clusters, where n is the number of cases (UNESCO designated sites), then merges the two that are most numerically similar so that n – 1 clusters remain. The closest cases continue to fuse at each stage until only one cluster is left, fused at a level that encompasses all the other clusters (and thus, cases) and giving rise to the cluster's hierarchical structure. Given that each fusion remains in place throughout the process, the stage at which each cluster is merged is especially relevant because it marks the degree of efficiency in making the fusion: those merging later in the process require more "effort" to fuse. In this instance, the process indicated that designated sites that merged later were less similar in the range of threats they faced than sites that fused at earlier stages.

All clustering procedures use distance measures to combine clusters, but because differences between methods arise as a result of the different ways of defining distance (or similarity) between objects, it is possible for different hierarchical clustering procedures to produce different solutions. Therefore, in using such a technique, it is important to apply different methods and to note which results exhibit the most consistency. The results presented here use Ward's clustering method, which calculates the sum of squared Euclidean distances from each case in a cluster to the mean of all variables, with the cluster to be merged being that which increases this sum the least.[2]

A hierarchical cluster analysis may be represented visually in a dendrogram, which is a two-dimensional diagram resembling a tree whose branches illustrate the fusions or divisions made at each successive stage of the clustering process. In an agglomerative dendrogram (such as that used here), the horizontal scale indicates the distance at which the groups are clustered so that the fusions made first (and most efficiently) appear nearest to this axis. To assist with interpretation, the original distances are rescaled as whole numbers between

1 and 25, although the ratio of the rescaled distances within the dendrogram is the same as the ratio of the original distances.[3] The diagram also resembles an evolutionary tree, indicating the development of relationships between clusters.

UNESCO designated sites whose combination and magnitude of *specific threats* were deemed most similar were joined first, and these links appear nearer to the left of the dendrogram, with a rescaled cluster combination distance closer to zero. Subsequent fusions between clusters of designated sites occur further along the horizontal scale, to the right of the dendrogram. In determining group membership, there should be a division before a fairly large horizontal range where the number of groups does not change. From the resulting dendrograms, it is possible to distinguish some groups that emerge from the hierarchical cluster analysis more easily than others. By measuring the mean scores for each group of designated sites according to the balance of *specific threats* evaluated, we can identify the key characteristics of each group and, therefore, those designated sites that share a common range and magnitude of threats.

The analysis was performed using IBM SPSS software v.24.

Survey results

Background information

Table 4. Number of full-time equivalent paid staff

	Total number of sites	0	1	2 to 3	4 to 10	10 or more
UK	22	3	5	6	6	2
Canada	19	1	3	3	9	3

Table 5. Number of volunteers available to UNESCO designated sites in Canada and the UK

	Total number of sites	0	1 to 9	10 to 20	21 to 49	50 or more
UK	22	3	4	5	2	8
Canada	19	7	3	3	3	3

Table 6. Number of sites with human resources assigned to maintain a geographic information system (GIS) for the designation

	Total number of sites	No human resources assigned to GIS	No human resources assigned to GIS, but a partner organization or consultancy has human resources assigned to maintaining a GIS (permanent)	No human resources assigned to GIS, but a partner organization or consultancy has human resources assigned to one-off GIS projects (temporary)	Human resources assigned to maintain a GIS
UK	22	1	6	6	9
Canada	19	4	3	2	10

Analysis of threats

Table 7. Breakdown of the top 10 *specific threats*

Top 10 *specific threats*	Number of sites citing threat	% of sites citing threat	Number of sites citing as a top 3 threat	% of sites citing as a top 3 threat	Trend
Flooding	27	66%	8	20%	Increasing 100%
Financial resources	27	66%	7	17%	Increasing 100%
Impacts of tourism, visitation and recreation	24	59%	11	27%	Increasing 100%
Storms	24	59%	4	10%	Increasing 100%
Human resources	23	56%	4	10%	Increasing 100%
Invasive and/or alien terrestrial species	18	44%	2	5%	Increasing 100%
Housing	16	39%	10	24%	Increasing 100%
Commercial development	14	34%	6	15%	Increasing 100%
Identity, social cohesion, changes in local population and community	13	32%	7	17%	Increasing 100%
Other climate change impacts	11	27%	11	27%	Increasing 100%

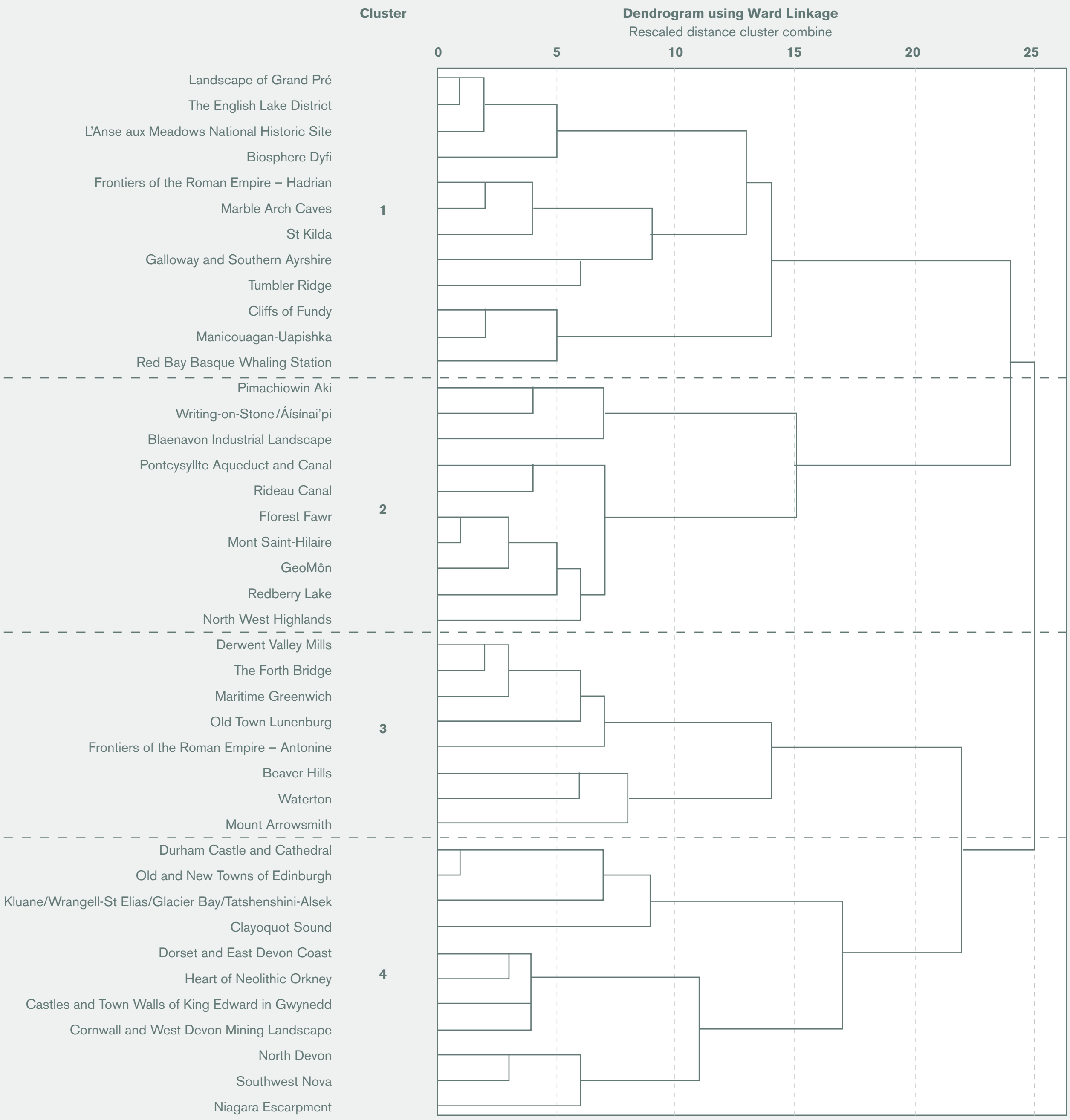
Table 8. The top 10 specific *categories of threat*

Category of threat	*Specific threat* (percentage of sites citing)
Climate change and severe weather events	Flooding (66%) Other climate change impacts (27%) Storms (59%)
Management and institutional actors	Financial resources (66%) Human resources (56%)
Social and/or cultural uses of heritage	Impacts of tourism, visitation and recreation (59%) Identity, social cohesion, change in local population and community (32%)
Invasive and/or alien species or hyper-abundant species	Invasive and/or alien terrestrial species (44%)
Buildings and development	Housing (39%) Commercial development (34%)

Cluster analysis

The dendrogram in Figure 1 illustrates the clustering of all designated sites in the study (that is, biosphere reserves, global geoparks and World Heritage Sites in Canada and the UK) and their division into four main clusters (numbered 1 to 4). Because we used a hierarchical cluster analysis, the number of groups was not determined a priori; the clusters were created by interpreting the dendrogram.

Figure 1. Dendrogram of cluster analysis of all groups (Ward's method), annotated to show the identification of four distinctive clusters



In this case, the four groups start to emerge about halfway along the x-axis (a rescaled distance of around 15) and far after most of the individual designated sites have been joined together. The greatest density of connections occurs below a rescaled distance of around 5 on the x-axis, with some pairs of designated sites fusing at the first possible step (i.e., Landscape of Grand Pré and the English Lake District in cluster 1; Fforest Fawr and Mont Saint-Hilaire in cluster 2; and Durham Castle and Cathedral and Old and New Towns of Edinburgh in cluster 4).

Although the results of the cluster analysis are useful in determining which designated sites share a common range and magnitude of threats (and therefore how they can be grouped accordingly), the dendrogram does not explain the factors behind the clustering. In a cluster analysis, a proximity matrix can be created to indicate the numerical distances between cases and can therefore be used to explain how each cluster was formed at successive iterations. However, for our purposes, it is more revealing to examine the characteristics of the clusters themselves according to their relative similarities and differences versus the other clusters. This helps us to determine what typifies each of the four clusters according to the combination of threats identified.

By calculating the mean values for each variable (that is, the *specific threat*) for each of the four clusters, it is possible to identify their key characteristics in terms of the range of threats and their relative magnitude. Plotting these means on similar axes reveals the unique "signature" for each cluster, indicating the combination of threats and their relative magnitudes.

Figure 2 presents these results for each of the four clusters identified in Figure 1. It reveals that each cluster has a unique signature that may be interpreted to show how its designated sites are distinctive from those within other clusters. For example, the first cluster (blue line) returns uniquely high mean scores for storms, flooding, erosion and deposition, forestry/wood production, and livestock farming/grazing of domesticated animals. It also exhibits uniquely low mean scores for housing and management activities. This combination distinguishes this cluster from other clusters, and vice versa.

This graph can be summarized to indicate the characteristically high and low mean scores for each cluster relative to one another and, in effect, to indicate the key threats that distinguish each cluster of UNESCO designated sites. The diagram in Figure 3 provides this information for each of the four clusters and indicates the country in which the designation is based (Canada or the UK) and its type (biosphere reserve, global geopark or World Heritage Site).

Figure 2. Balance of threats by cluster: mean scores for the range of *specific threats* in each of the four cluster groups

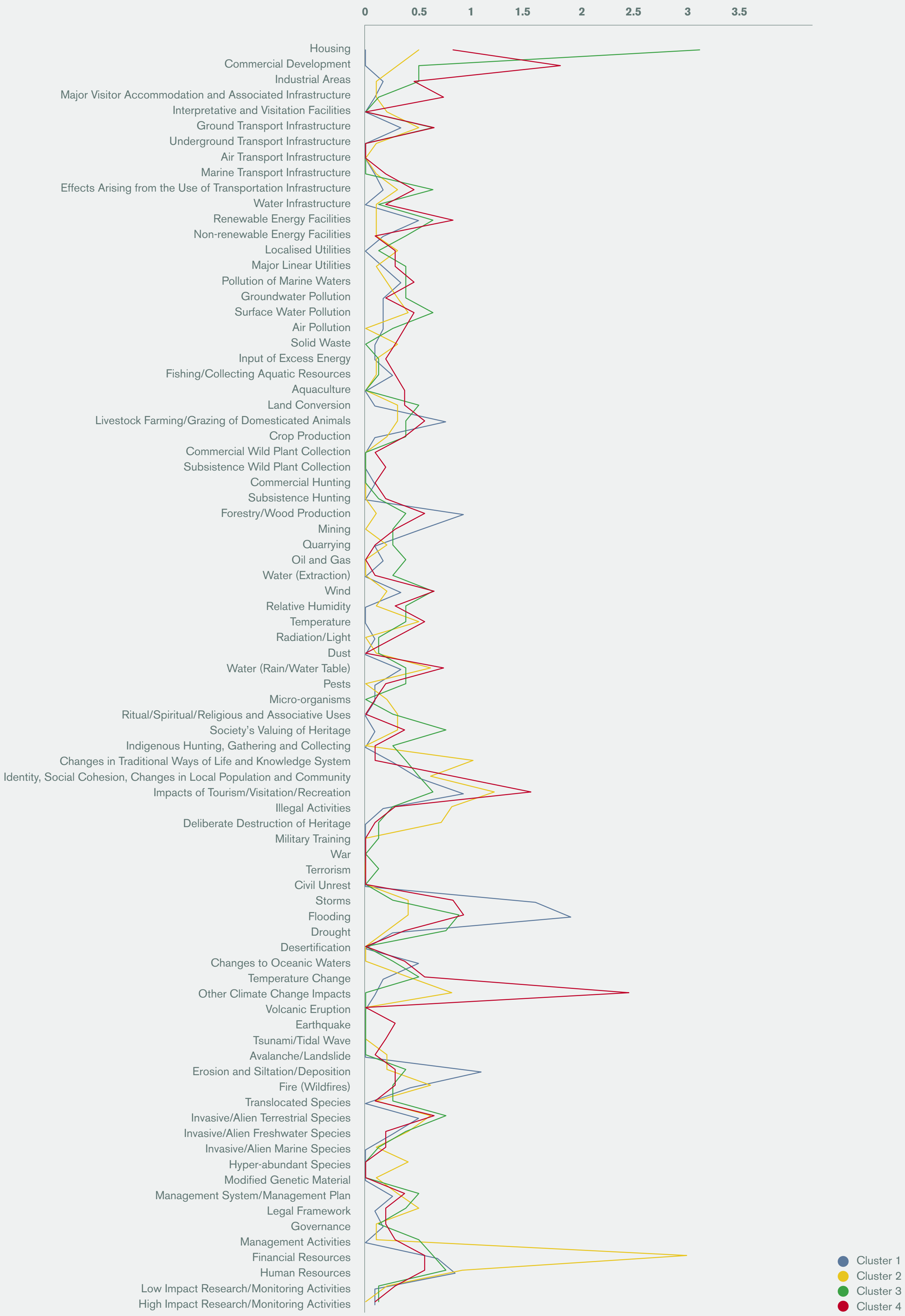


Figure 3. This diagram shows the key characteristics of the range and magnitude of threats for each cluster derived from the cluster analysis of all designated sites and a comparison of their mean scores. The cluster threat level provides an interpretation from the mean scores for each threat, based on whether the mean is highest among the four clusters and an outlier (high), relatively high (moderate), or lowest among the clusters (low).

Cluster 1
Flooding
Storms
Erosion and Siltation/Deposition
Forestry/Wood Production
Livestock Farming/Grazing of Domesticated Animals
Human Resources
Housing
Management Activities
Biosphere Dyfi (UK)
Cliffs of Fundy (CAN)
Frontiers of the Roman Empire – Hadrian's Wall (UK)
Galloway and Southern Ayrshire (UK)
Landscape of Grand Pré (CAN)
L'Anse aux Meadows National Historic Site (CAN)
Manicouagan-Uapishka (CAN)
Marble Arch Caves (UK)
Red Bay Basque Whaling Station (CAN
St Kilda (UK)
The English Lake District (UK)
Tumbler Ridge (CAN)

Cluster 2
Financial Resources
Changes in Traditional Ways of Life & Knowledge System
Human Resources
Illegal Activities
Deliberate Destruction of Heritage
Impacts of Tourism/Visitation/ Recreation
Hyper-abundant Species
Other Climate Change Impacts
Air Pollution
Forestry/Wood Production
Blaenavon Industrial Landscape (UK)
Fforest Fawr (UK)
GeoMôn
Mont Saint-Hilaire (CAN)
North West Highlands (UK)
Pimachiowin Aki (CAN)
Pontcysyllte Aqueduct and Canal (UK)
Redberry Lake (CAN)
Rideau Canal (CAN)
Writing-on-Stone/Áísínai'pi (CAN)

Cluster 3
Housing
Society's Valuing of Heritage
Surface Water Pollution
Groundwater Pollution
Invasive/Alien Terrestrial Species
Management System/Management Plan
Impacts of Tourism/Visitation/Recreation
Beaver Hills (CAN)
Derwent Valley Mills (UK)
Frontiers of the Roman Empire – Antonine Wall (UK)
Maritime Greenwich (UK)
Mount Arrowsmith (CAN)
Old Town Lunenburg (CAN)
The Forth Bridge (UK)
Waterton (CAN)

Cluster 4
Commercial Development
Other Climate Change Impacts
Impacts of Tourism/Visitation/Recreation
Visitor Accommodation & Associated Infrastructure
Renewable Energy Facilities
Water (Rain/Water Table)
Oil and gas
Castles and Town Walls of King Edward in Gwynedd (UK)
Clayoquot Sound (CAN)
Cornwall and West Devon Mining Landscape (UK)
Dorset and East Devon Coast (UK)
Durham Castle and Cathedral (UK)
Heart of Neolithic Orkney (UK)
Kluane/Wrangell-St Elias/Glacier Bay/ Tatshenshini-Alsek (CAN)
Niagara Escarpment (CAN)
North Devon (UK)
Old and New Towns of Edinburgh (UK)
Southwest Nova (CAN)

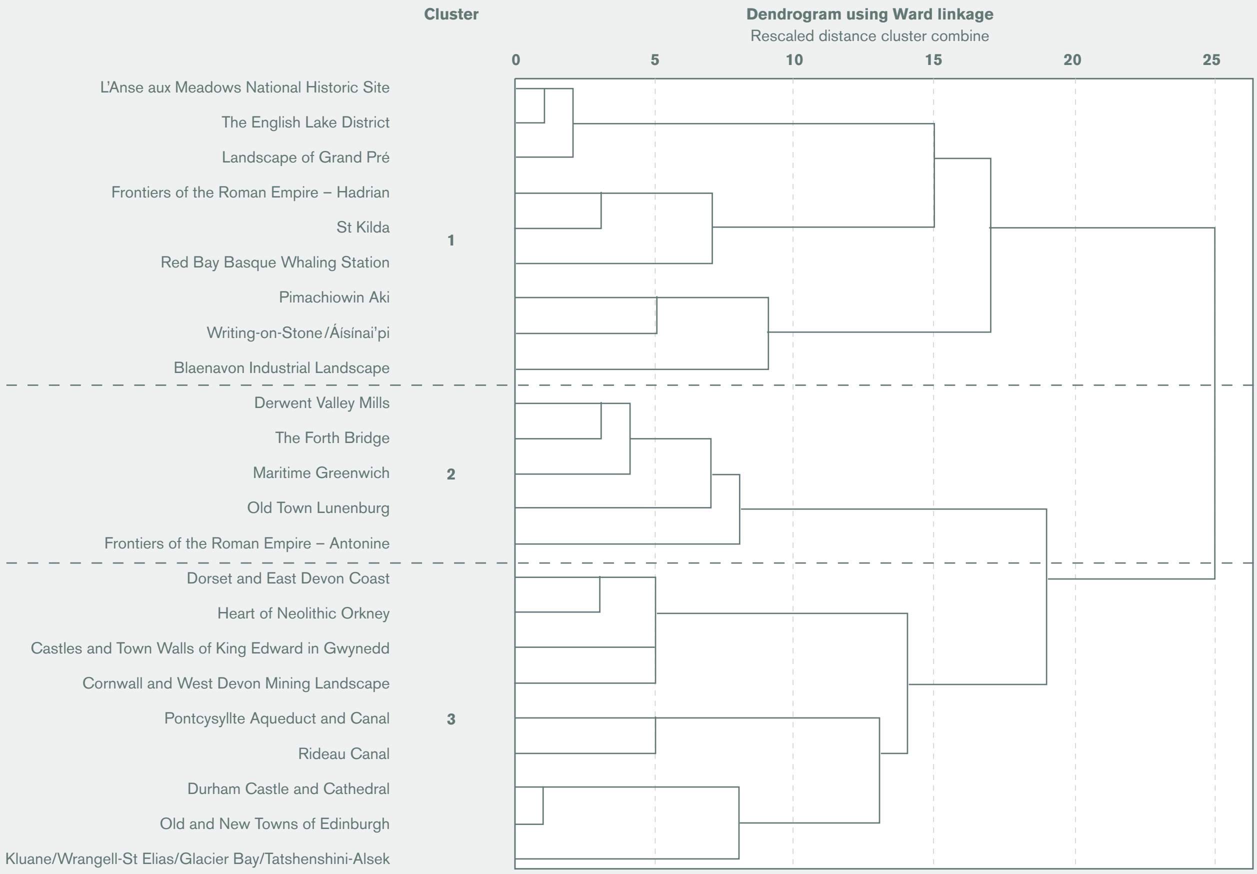
Cluster Threat Level
High
Moderate
Low

Designation Type
Biosphere Reserve
Global Geopark
World Heritage Site

It is possible to apply the same methodology to a particular type of designation to identify distinctive clusters. This would have value, for example, in bringing together sites of the same type of designation that may share other similarities (such as reporting methods). It could also serve to identify sites that could collaborate more closely.

Since at 23, the number of World Heritage Sites is the highest in the sample and represents a range of locations within Canada and the UK, we applied a cluster analysis to establish groups based on their similarities and differences using the same methodology described above. The resulting dendrogram (Figure 4) indicates that three distinctive clusters could be established. Again, most cases fuse fairly easily (toward the left of the dendrogram), allowing a rescaled distance of 15 to serve as a threshold for separating the clusters. Because this analysis omits other designation types, some sites fuse together more easily than in the previous analysis. For example, L'Anse aux Meadows National Historic Site now joins the English Lake District at the first stage. However, there are also ongoing similarities, with the Durham and Edinburgh sites still fusing at the first stage (as shown in Figure 4), suggesting that the methodology is robust enough to be applied to smaller (23) and larger (41) sample sizes.

Figure 4. This dendrogram of a cluster analysis of World Heritage Sites (Ward's method) shows the identification of three distinct clusters.



In comparison with the cluster analysis of all designated sites, the formation of the smaller cluster (2) and the late stage at which this cluster fuses with clusters 1 and 3 suggest that these World Heritage Sites (four out of five of which are located in the UK) possess characteristics that are less common in the other clusters.

By plotting the mean values for each *specific threat*, it is again possible to visualize the defining features of these three clusters (Figure 5). The lines for each cluster indicate the range of threats and their relative magnitudes and, therefore, how the clusters may be distinguished.

Cluster 1 scores uniquely highly for storms, flooding and changes in traditional ways of life and knowledge systems, but uniquely lowly for housing and commercial development; cluster 2 has particularly high scores for commercial development, impacts of tourism, visitation and recreation and other climate change impacts, but low scores for changes in traditional ways of life and knowledge systems; cluster 3 is dominated by housing issues, with high scores for society's valuing of heritage and relatively low scores for human resources.

A closer examination reveals that all sites in cluster 2 identified housing as either their greatest or second-greatest threat (Table 9).

Table 9. Cluster 2 sites share a concern about housing

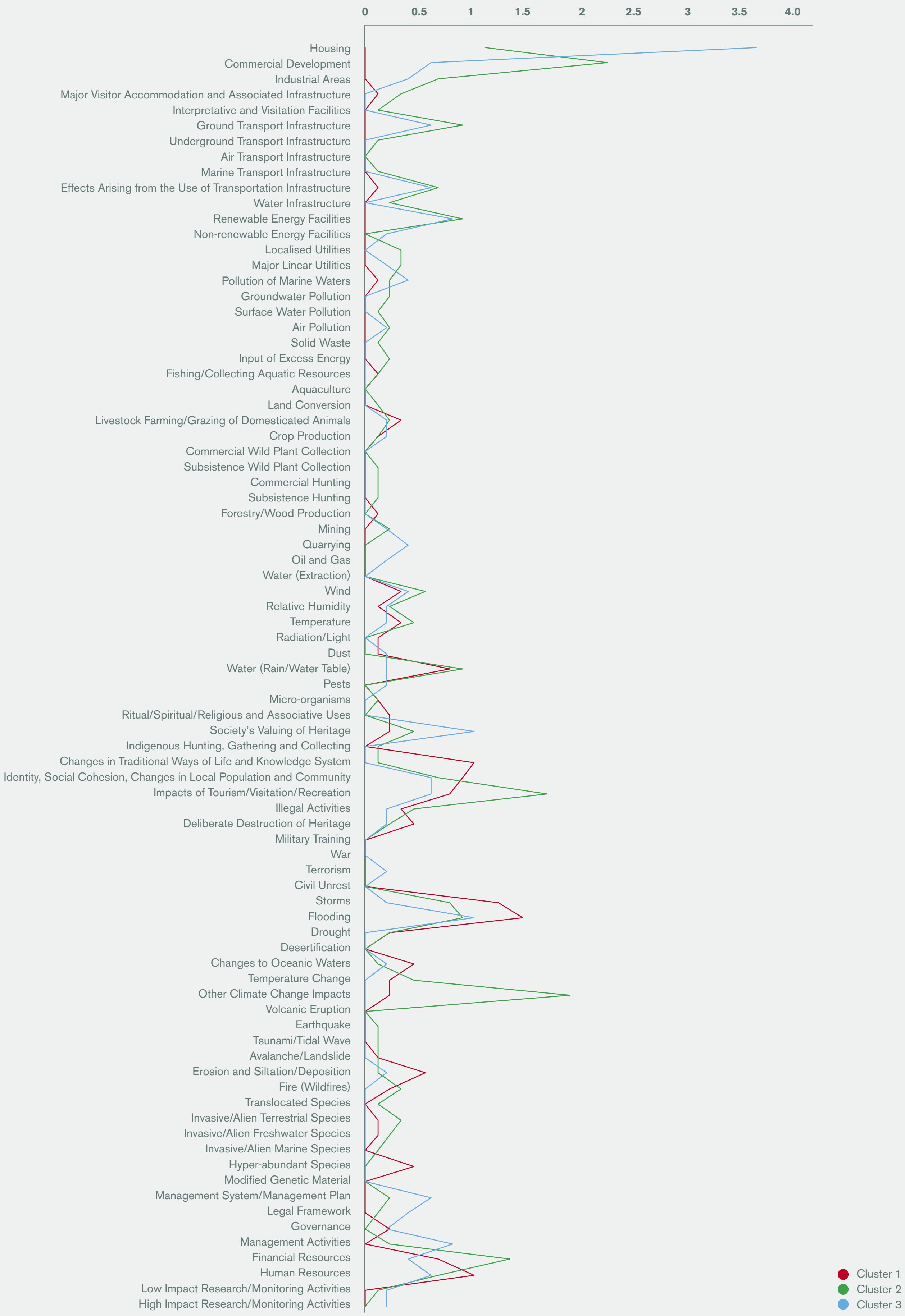
Site	Threat 1	Threat 2	Threat 3
Frontiers of the Roman empire – Antonine	Society's valuing of heritage	Housing	Commercial development
Old Town Lunenburg	Management activities	Housing	Identity, social cohesion, changes in local population and community
Derwent Valley Mills	Housing	Flooding	Human resources
The Forth Bridge	Housing	Renewable energy facilities	Wind
Maritime Greenwich	Housing	Impacts of tourism, visitation and recreation	Transportation infrastructure

L'Anse aux Meadows National Historic Site and the English Lake District join at the first stage and before all others within the first cluster, despite being located in different countries. A closer analysis of the survey results shows that both sites are most concerned about the same three *specific threats*, albeit in a different order (Table 10).

Table 10. Cluster 3 sites share the same top 3 concerns despite being located in different countries

Site	Threat 1	Threat 2	Threat 3
L'Anse aux Meadows National Historic Site	Impacts of tourism, visitation and recreation	Flooding	Identity, social cohesion, changes in local population and community
English Lake District	Flooding	Identity, social cohesion, changes in local population and community	Impacts of tourism, visitation and recreation

Figure 5. Balance of threats by cluster (for World Heritage Sites), with mean scores for the range of specific threats in each of the three cluster groups



Use of geographic information system to manage threats

Figure 6. A look at how sites currently use GIS

Do you currently use a GIS to assist with the management of your UNESCO designation?

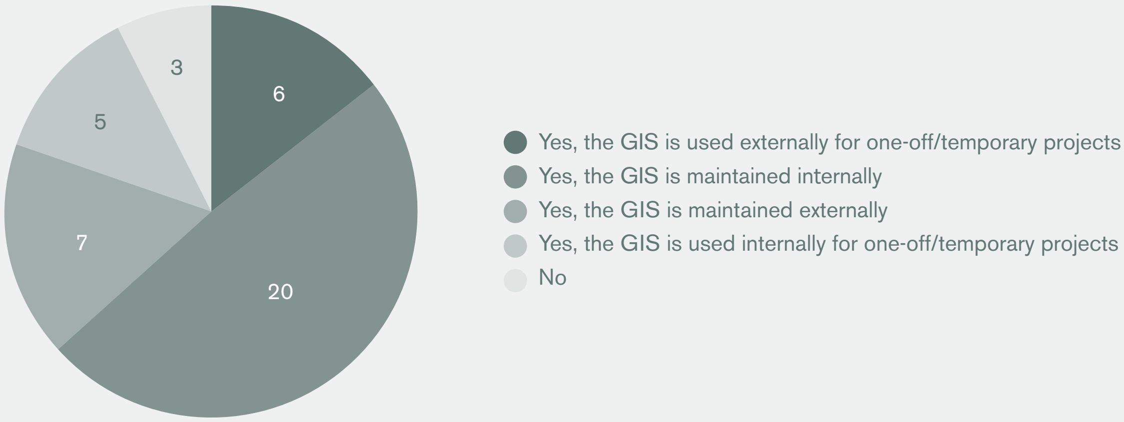


Figure 7. A look at which GIS software sites use

Which GIS software to you use?

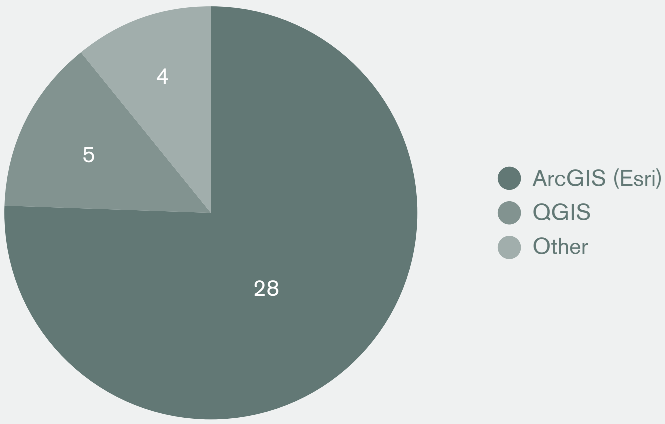


Figure 8. Answers corresponding to how often sites use GIS tools

How often do you use GIS?

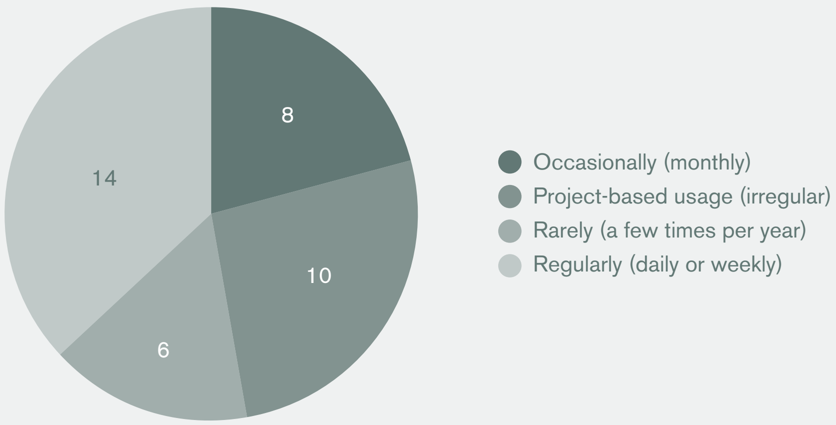


Table 11. Responses to the question "What do you use GIS for?"

Activity	% of sites
Centralized spatial database for storing site data	56
Spatial analysis (e.g., for designation report, review or revalidation)	73
Facilities management	15
Visitor management	10
Conservation monitoring	61
Production of site maps for visitors	44
Environmental modelling	22
Predictive modelling	10
None of the above	2

Figure 9. Ordered percentages of geospatial data types held by sites

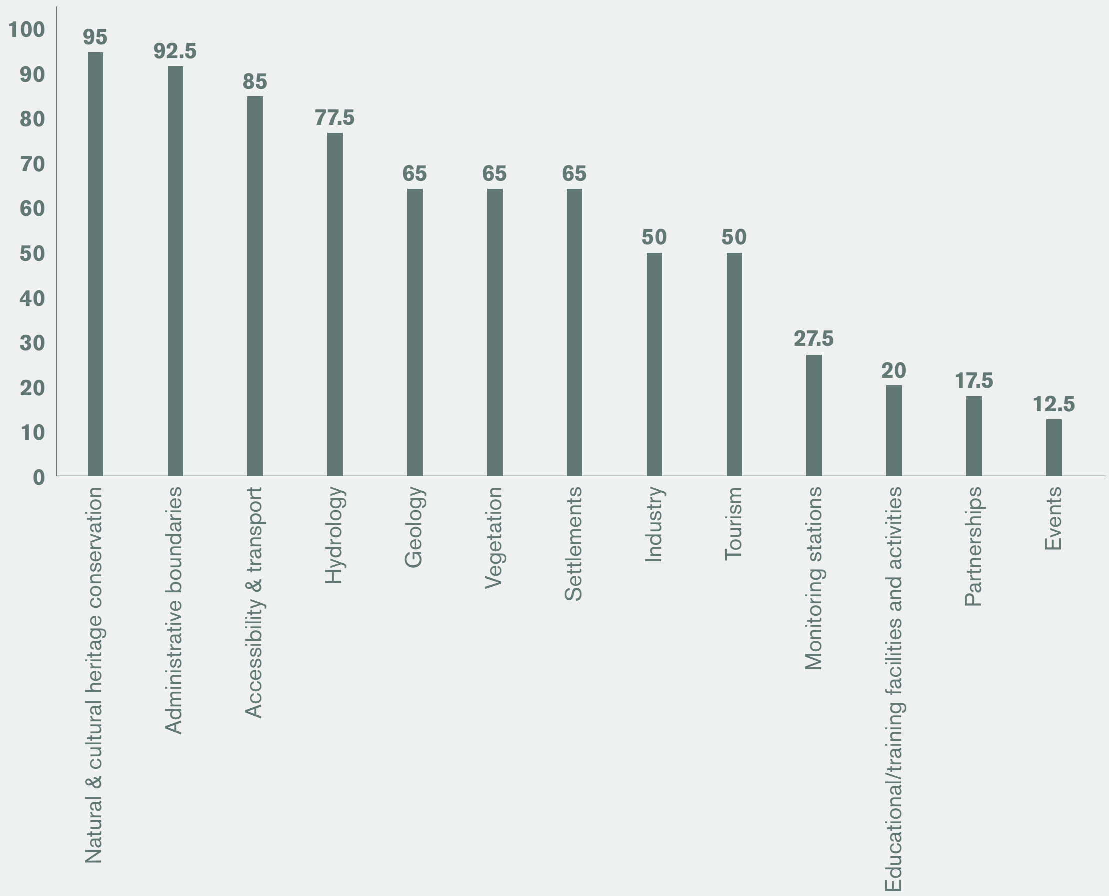


Table 12. Designated sites that use GIS to manage threats identified in the mapping survey

Site type	Designation	Threat management in GIS
Biosphere reserve	Beaver Hills	Surface water mapping and planning
	Southwest Nova	Interactive Science Atlas application
	Mount Arrowsmith	Imagery for forestry and housing research and strategies
	Galloway and Southern Ayrshire	Identification of locations for expansion of native woodlands
	North Devon	Monitoring water pollution and results; prioritizing and planning responses using models and analysis techniques
Geopark	Tumbler Ridge	Locating areas of disturbance, reporting damaged or disturbed areas to authorities
	GeoMôn	Use of aerial photos, location of sites and features
	Marble Arch Caves	Aerial photography for damage to Cuilcagh due to social and/or cultural uses of heritage
World Heritage Site	Red Bay Basque Whaling Station	Mapping locations of sites, shorelines and other features
	Rideau Canal	Invasive species monitoring, tracking development
	Kluane/Wrangell-St. Elias/ Glacier Bay/Tatshenshini-Alsek	Tourism activities planned based on spatial and conservation datasets from GIS
	Pimachiowin Aki	Wildlife habitat modelling
	Antonine Wall	Assessing risk, managing designations and considering the impact of proposed works on the site
	Hadrian's Wall	Monitoring trends and identifying patterns
	Dorset and East Devon Coast	Monitoring management practices and sea level rise in GIS systems that provide data related to management boundaries, designations, climate change and coastal monitoring
	Pontcysyllte Aqueduct and Canal	Controlling development and monitoring invasive species
	Derwent Valley Mills	Checking whether new development falls in or close to the site and buffer zone
	Cornwall and West Devon Mining Landscape	Informing planning advice responses made by the site office to achieve the preservation of Outstanding Universal Value
	St Kilda	Monitoring built heritage with database of buildings and records of repair
	Castles and Town Walls of King Edward in Gwynedd	Checking constraints against all planning applications within 3 km of the site; collect climate change and flood zone spatial data within areas at risk, for flood and coastal management around site

Table 13. Summary of responses provided by sites when asked about the challenges they face in the use of geospatial data

Designation type	Geospatial data challenges
Biosphere reserves	Staff capacity and expertise
	Costs of obtaining data
	Equipment costs
	Licence costs
	Data management
	Intellectual property rights and/or data-sharing agreements
Global geoparks	Equipment costs
	Complexities associated with certificates and licences for cross-border data
	Staff training costs
	Cost of software and data
World Heritage Sites	Data not available
	Staff capacity
	Lack of good underlying satellite imagery
	Licence costs
	Copyright and intellectual property rights

Section 3: Review of periodic reporting

To identify the common threats faced by the three types of UNESCO designated sites, we performed a review of periodic reporting outcomes.

For biosphere reserves and geoparks, we reviewed reports from 2016 to 2019 (that is, since the first geopark revalidations). We also reviewed sites worldwide due to the small number of periodic reviews and revalidations performed for Canada and UK biosphere reserves and geoparks, respectively, in that time frame.

For biosphere reserves, we examined the International Co-ordinating Council of the Man and the Biosphere Programme reports for 2016 to 2019 and listed the reasons why sites were considered not to have met the programme criteria by year, site and country. In many cases, the council had determined that there was insufficient information to determine whether the site met or did not meet the criteria of the Statutory Framework of the World Network of Biosphere Reserves. These sites were not included in the analysis. Sites that submitted follow-up information from periodic reviews in previous years were also excluded.

For geoparks, we examined the reports of the Global Geoparks Council for 2016 to 2019 and collated the reasons why sites received a yellow or red card.

For World Heritage Sites, data from state of conservation reports for Europe and North America were extracted from the UNESCO database by searching for Europe and North America, 2016 to 2019 and grouped by threat.[4]

We also analyzed data from the second cycle of periodic reporting (2012 to 2015)[5] to compare commonly identified threats in North America and Europe.

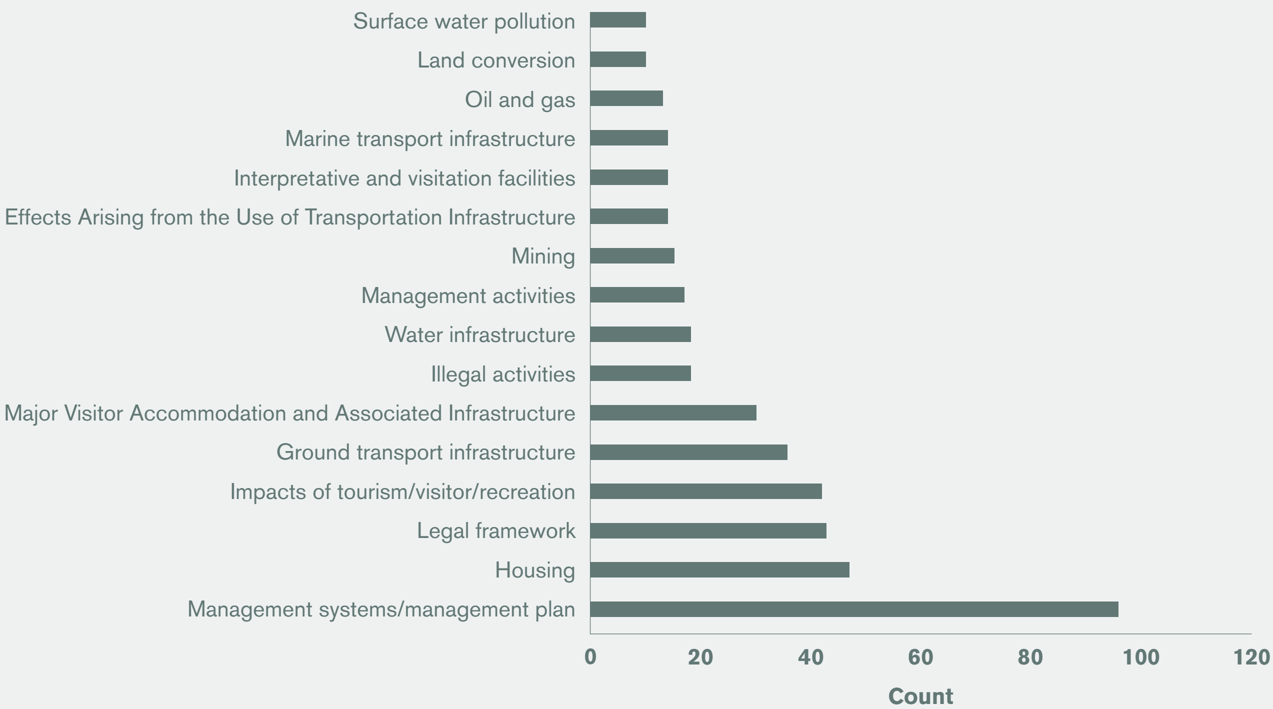
Table 14. Reasons for biosphere reserves not meeting the Statutory Framework of the World Network of Biosphere Reserves criteria during the 2016 to 2019 periodic reviews

Reason	Count
Lack of zonation rationale (no zonation, no buffer zone, rationale missing)	45
Lack of community involvement (little involvement or no inhabitants)	26
Lack of management plan	22
Not performing 3 functions	16
Governance issues (financial and human resources, governing body lacking)	14
Lack of zonation map	11
Lack of research and monitoring	4
Impacts of industry (oil exploitation, tourism, wind farms)	4

Table 15. Reasons for geoparks receiving a yellow or red card during the 2016 to 2019 revalidations

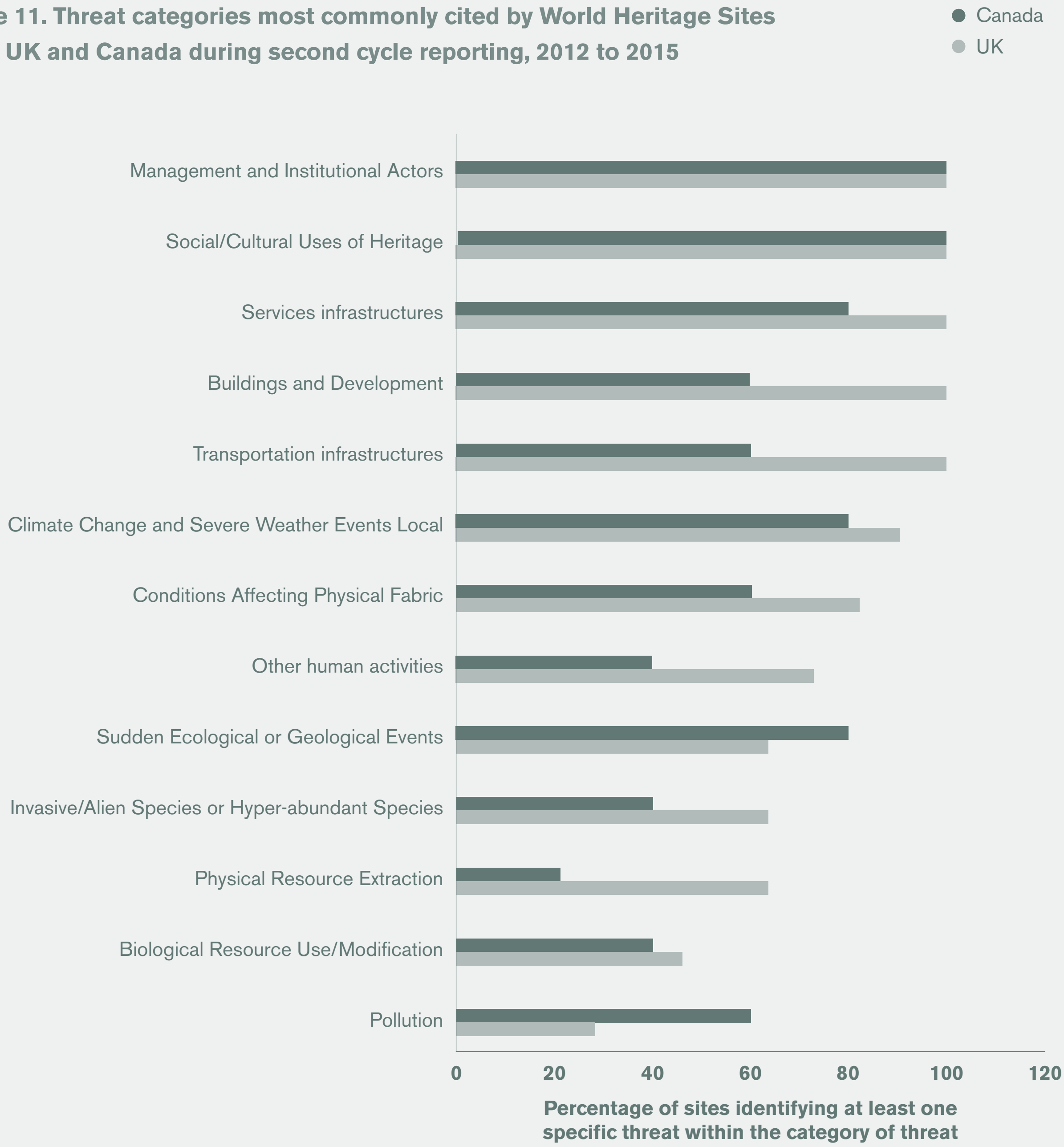
Reason	Count
Lack of visibility	12
Insufficient human resources	9
Lack of community engagement	5
Lack of networking and participation	5
Boundary issues	4
Insufficient financial resources	2
Lack of management plan	2
Sustainable development not achievable	2
UNESCO logo use issue	1
Sale of geological material	1

Figure 10. Threats commonly identified by World Heritage Sites in state of conservation reports from 2016 to 2019



Between 2016 and 2019, 63 World Heritage Sites had submitted a total of 139 state of conservation reports identifying a total of 588 specific threats over the four years. Sixteen specific threats were identified more than 10 times over the four years. The axis shows the number of times these specific threats were identified.

Figure 11. Threat categories most commonly cited by World Heritage Sites in the UK and Canada during second cycle reporting, 2012 to 2015



Section 4: Data for sites for sustainable development

1. Data catalogues, governance and standards

Constructing a central data catalogue is no small feat. However, by thinking about such a data register, sites could improve their understanding of their data holdings, for example:

- What data do they have?
- How complete are the data?
- What format are the data in?
- Who owns the data?
- Can the data be shared? With whom and at what cost?
- How up to date are the data?
- If the data are refreshed on a regular (or not so regular) basis, how timely are they?
- Can the data be assessed for accuracy?
- What are the lineages of the data? Have they been changed or modified in any way?
- For what purpose were the data collected, and how can they be used (licence)?
- Can the quality of the data be assessed?
- Do the data conform to any standards (e.g., national or international)?

Data catalogues can centralized or held individually by organizations, with distributed or public access. Both methods come with challenges: who will maintain the catalogue, and how will access be granted? The advantage of a centralized catalogue is that it is much easier for sites to search for and identify data that might interest them because the data are collected, held and maintained by others and can be found in a single place. Sites can also see where others may be using data that they themselves hold, but for a different purpose. In this way, sites can gain an implicit understanding of wider data use without the need for complex knowledge transfer activities.

However, one concept to be mindful of is that although centralizing access to such a catalogue would increase visibility and uptake, the contributions to the catalogue should be decentralized. Instead of relying on a top-down data management structure, sites should be empowered to curate the catalogue themselves, thereby reducing the administrative burden and any delays in waiting for a central UNESCO resource to apply changes.

Often, data catalogues are used to store only the raw data that an organization has collated. However, by storing and making available both “engineered” or “transformed” data as well as the outputs generated from these data (such as output reports, dashboards, presentations and multimedia), organizations and sites can learn from the efforts of others more directly. A key aspect of this is the ability to trace the lineage of any data source, whether primary or secondary in nature, engineered or otherwise. This allows users to have greater confidence in their understanding of where the data have come from and allows other data consumers to trace the data back to their origins.

Having a data catalogue of references to data items does not automatically mean that sites are required to offer up their data to anyone. Any such catalogue can provide metadata, links and access control rights that require a user or site to request permission to see or make use of the data. This is akin to data publishing and citation standards, such as the Digital Object Identifier system,[6] which promotes open data values but does not insist on citations linking directly to data. Principles such as those described by the UK Open Data Institute’s Data Spectrum[7] can also be reflected, with data ranging from open to closed, as well as other conceptual access control methods for regulating access to data, such as the Five Safes[8] described by the UK Data Service.

Additionally, as is good practice in any data stewardship endeavour, any data tooling that is to be exposed – whether internally within a site or externally to others – should be designed with the FAIR Guiding Principles in mind.[9] These principles requires that not only the data, but also any supporting metadata, be Findable, Accessible, Interoperable and Reusable. The principles can be achieved by "baking in" a set of core design ideas and engineering approaches while taking particular account of the concepts of the semantic web, open data standards and internationally recognized core data management vocabularies.[10] In this way, we can also design a complete data architecture with complementary systems that not only demonstrate openness where required, but also provide controls around the discoverability and usage of data, such as in cases where sites or nations may wish to restrict the use – or even the knowledge – of particular data and resources.

2. Mapping for participatory management of UNESCO designated sites

It is important to acknowledge that GIS approaches can be top-down, with parameters set by internal operations management and research and evaluation requirements or by external factors and bodies (rather than bottom-up by meeting the needs and expectations of local and Indigenous communities). If what is mapped tends to correlate with what is regarded as having value, who determines what is valuable and to whom?

For example, although GIS provides an integrated database for storing, analyzing and exploring spatial relationships, it relies on a Western paradigm of mapping that assumes everything can be located and plotted according to a Cartesian definition of space (e.g., latitude, longitude and altitude). Non-linear or intangible phenomena escape classification in this way. Moreover, maps are, effectively, instruments of power (as exercised through the selection and appearance of features); as a result, the politics of representation tend to reflect organizational definitions of what is valued and worth recording. Local concerns are often missed. Finally, although initiatives such as public participatory GIS can be helpful in recording and mapping phenomena that are valued by local communities but absent on official maps, this approach still relies on Western notions of cartography (formalized map making). The premise is to conform to a process of capture, record and possess, and is often imposed upon non-Western cultural contexts.

Any approach to geospatial data and its use in the sustainable development of UNESCO sites must be tailored to the local community and sensitive to an understanding of different ways of "mapping." If mapping can be described as a language for expressing space and place, an approach is needed that invites local communities to map UNESCO designated landscapes using their own methods, which may or may not be directly compatible with GIS or even Western mapping paradigms.

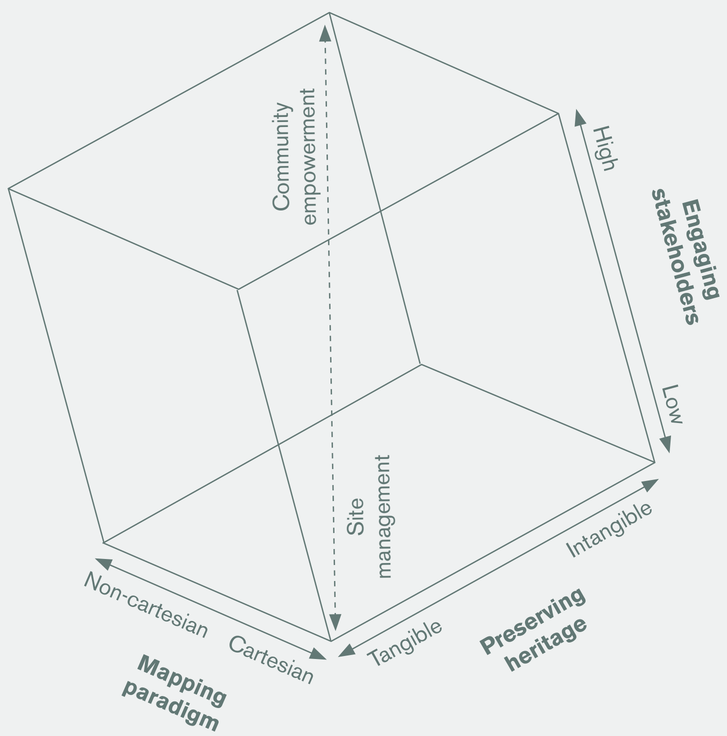
The approach to mapping recommended here encompasses a diversity of approaches that may be arranged as a continuum from the collection of new geospatial datasets for the internal management of the site to the mapping of intangible phenomena by Indigenous Peoples to enhance stewardship and define cultural value. The language of mapping encompasses this breadth of portrayal and provides scope for widening participation as well as strengthening stakeholder engagement.

Table 16. Approaches to mapping

Purpose	Engagement	Example
• Internal site management	• Total site staff • No local population • No global population	Collecting site boundary data for the site GIS from a national mapping organization
• Internal site management • Stakeholder engagement	• High site staff • Low local population • No global population	Collecting data on the location of an endangered species of vegetation that is valued by the local population to be put into the site GIS
• Stakeholder engagement • Widening participation	• Low site staff • High local population • Low global population	Allowing local populations to “map” the site in their own way (by selecting and portraying features) to capture the unique cultural value of the site and preserve the unique aesthetic of the population’s approach to mapping it. The results could be accessed on the site’s website and displayed in visitor centres.

The diagram in Figure 12 explains how the approaches in the Table 16 are inter-related. The axes define the key approaches and activities adopted (preserving heritage, engaging stakeholders and the mapping paradigm). Prioritizing site management would combine a Cartesian mapping paradigm with preserving tangible heritage and a relatively low level of engagement with stakeholders. In contrast, prioritizing community empowerment would see high levels of engaging with stakeholders, preserving intangible heritage and adopting a non-Cartesian mapping paradigm where necessary.

Figure 12. A site sustainability cube showing inter-related approaches to site mapping



Although GIS can be an effective management tool that unites stakeholders in collecting and sharing information, this paradigm of mapping requires phenomena to be objective, tangible features in the landscape that can be plotted and measured. This approach is useful for capturing data for site management and conservation purposes (such as for monitoring invasive species), but tends to overlook intangible phenomena such as society's valuing of heritage.

Approaching mapping from an anthropological perspective respects different cultural traditions and allows local populations to define what is important to them and portray it in their own way. It presents an opportunity to widen community participation, nurture a sense of stewardship and shared ownership of designated sites, build partnerships and effectively manage all components of landscapes.

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