Wear processes in architectural heritage: definition, studies, contrasting measures. The case of UNESCO World Heritage Site "Venice and its Lagoon"

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1. Contextualizing research activity

The UNESCO World Heritage Site "Venice and its Lagoon" has recently adopted a Management Plan, developed between 2009 and 2012, involving all the numerous subjects operating in various areas in territorial governance[1].
The plan is a rare opportunity to observe, identify and describe the current management and planning methods and the series of critical problems attributable to the complexity of the issues that characterize the site. It also defines a management system that is based on the values that motivated registration on the World Heritage List and carries out an integrated analysis of the state of the site; this examination highlights the forces of change underway, identifying the future objectives that can be achieved via the various intervention options and the possible strategies of protection and consolidation, assessing the possible impacts on the local system, defining the action plan to achieve the targets set, defining the coordination and implementation methods and assessing achievement through a series of indicators that implement the systematic monitoring of the results over time.
Given the particular physical and landscape characteristics of the site (that contribute to its exceptional value but, at the same time, constitute a factor of vulnerability), the projects identified in the plan define actions that primarily target objectives linked to protecting and preserving the site and promoting its sustainable use.
By analyzing the modifying forces underway on the site, the plan also identifies "macro-emergencies"; in other words, the main phenomena that negatively influence the natural and environmental protection of the lagoon and the systemic preservation of the site's heritage assets. These include the phenomenon of high tide, the swell caused by the wind and traffic on the water, pollution, problems linked to decay of the built heritage and paving, and changes in use due to the gradual decline in the resident population and changes to the structure of local trade, as well as growing anthropic pressure from increasing tourists flows, which can easily be identified as one of the main causes of the phenomena described above[2].
In relation to these phenomena, the plan requires the identification of appropriate mitigation actions[3].
Although several of the critical issues identified above have for some time been the focus of study by various bodies that operate on the Venetian territory[4], even through the development of projects - that have either concluded or

are in the realization phase - adopted in the Management Plan as “structural projects”, the level of in-depth analysis of the different dynamics that guide the phenomena indicated as macro-emergencies is not homogeneous, due also to the absence in some cases of appropriate monitoring criteria and parameters.
In this context, based on an initiative by the Municipality of Venice and in coordination with the Soprintendenza per i Beni Architettonici e Paesaggistici of Venice and its Lagoon, research activity has begun targeting the definition of methodologies aimed at identifying indicators and parameters with which to measure some phenomena that could influence the effect of wear processes and that could have negative repercussions on protection of the site.
From a methodological point of view, assessment of risk conditions[5] aims to describe, in systematic terms, the interaction between the urban-environmental system and the stresses the city is subjected to. In the case in question, assessment has focused on a geographical area identifiable as the old town centre of Venice, as an emblematic case of the potential critical conditions that the city and its lagoon[6], as well as art cities in general, are subject to.
The phenomena that are the object of study recall the macro-emergencies highlighted in the UNESCO Management Plan and express certain aspects of it.
In more detail, analysis focused on:
• the conditions of risk linked to the dynamics of visitor flows and the resulting tourism congestion generated;
• the gradual transfer to the mainland of managerial, administrative and even artisan functions, as well as those of a nature compatible with the urban fabric and supporting the resident population;
• the conversion of use of buildings from residential to facilities supporting the tourism offer, resulting in a reduction of available residential property, accompanied by high buying and selling and maintenance costs;
• the increasing in number of licenses for the occupation of public open spaces for private commercial activities;
• the processes of decay of elements near berthing areas;
• the processes of decay linked to the phenomenon of high tide and the gradual erosion of the banks due to the growing swell and pollution;
• the conditions of risk linked to logistics and the methods and means of supply;
• the conditions of risk linked to the production of waste and its disposal system;
• the conditions of risk linked to the perpetration of acts of vandalism on the building heritage (for example, graffiti);
• the conditions of risk linked to the presence of birds (pigeons, seagulls) or other colonizing animals.

Such stresses concern the physical-mechanical and chemical dynamics of the processes of decay generated by the agents that produce environmental aggression, but also by the processes of urban transformation and replacement of functions, as well as sociological and behavioural aspects linked to

the use of urban spaces. As a result, research required the adoption of a systemic and trans-disciplinary approach.
Moreover, precisely due to the fact that the dynamics of the wear processes are without doubt diversified, due to natural or anthropic agents, identifying effective strategies for controlling the processes and mitigation of the impacts cannot be limited to a sector approach, but necessitates development of a complex overall framework that takes into account the numerous, mutual interactions between the various phenomena.

2. Activities carried out and methodological approach

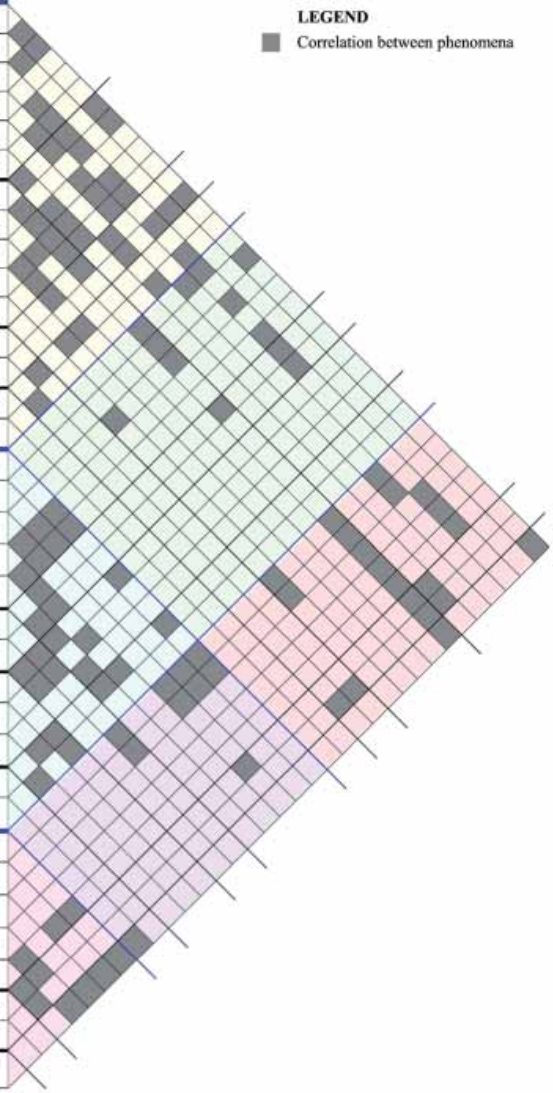
Research, which is still in the development phase, has focused on analysis of data on anthropic pressure, but also on identification of the parameters for assessing wear, intended in the broadest sense, that must be studied under various points of view:
- physical-mechanical type wear[7]: decay of materials (in particular, banks of the canals, paving of external and internal areas, vertical surfaces, especially in the parts up to a height of 2 metres from the ground). This may be due to:
    - phenomena of decay connected to anthropic pressure;
    - phenomena deriving from transport, supply and logistics activities;
    - the presence of colonizing animals;
    - phenomena deriving from traffic navigating the canals;
    - phenomena of decay deriving from atmospheric pollution, high tide, etc.
- wear deriving from perceptive-type phenomena[8]: aimed at assessing the phenomena of visual decay caused by overcrowding, improper use of urban spaces, waste production, effects of vandalism, etc.
- wear deriving from the processes of urban transformation[9]: aimed at assessing the interactions deriving from how urban space is used (processes of modification of the functions and models of use, increase in stallages, etc.)

These are complex phenomena and in some cases are also difficult to assess, not only because they are often fleeting, but also because they are heavily interrelated: each of the phenomena can be related to one or more wear processes and likewise in turn, each type of wear can be generated by several factors.
It was therefore necessary to place particular focus on the selection of data, the methods of interpreting the statistical indicators and the relationship between the phenomena.
An initial aspect of research referred to analysis of the phenomena related to tourism.
A considerable amount of information and data was selected, systematized through the analysis of databanks and other documentary sources available that led to the creation of a thematic register bringing together the main studies and research carried out in the recent past.
For this reason, some of the analysis was studied in greater depth in an attempt to define the places where anthropic pressure was concentrated, based on the most popular tourist itineraries.
Linked to the theme of anthropic pressure is the one regarding the dynami-

cs of the resident population (both inhabitants and city-users, with regard to concentration, favoured itineraries, meeting places, models of use for the city, etc.). In this case, it also proved necessary to assess the demographic trends regarding the age of the population and data on the transfer of residents from the old town to the mainland. Also being assessed is data on the dynamics of the real estate market, on disused accommodation facilities, on changes of ownership and on changes of use.
Also linked to the theme of anthropic pressure and tourism is that linked to the use of public spaces for tertiary activities. It is well-known that requests for the use of stallages are increasing considerably. At the moment, there is a lack of data on this topic. It will therefore be necessary to create an updated census of the areas in concession, the dynamics of transferring them and the characteristics of such stallages (configuration, size, models of use) in order to identify how and with what intensity these activities can contribute to producing both physical and perceptive “usage” of the old town.
Another piece of data analyzed concerned paving (“masegni”, made by trachyte, a stone pulled out from Euganean Hills) and cladding materials, their characteristics and diffusion, their state of preservation and their propensity to decay and data relating to the durability of the single materials.
With all probability, it will subsequently be necessary to develop experimental methods for measuring physical-mechanical wear that make it possible to link the presence of tourists/users in a given period of time and the deriving loss of material due to footfall or rubbing.
It is also necessary to study in more detail themes relating to the decay of such surfaces deriving from the presence of colonizing animals, in particular urban doves and seagulls, starting from the now well-known characteristics of decay linked to the action of these birds and the events that have led to sellers of bird food being moved away from the main tourist sites.
With regard to phenomena relating to the behaviour of tourists/residents, forms of urban decay caused by graffiti and vandalism have been highlighted. These types of action heavily influence both the forms of urban perception, giving a sensation of decay and negligence, and the dynamics of the physical decay of the materials as repeated operations to clean or “cover” dirty surfaces - especially when uncontrolled methods are adopted - inevitably lead to the loss of material.
The theme of the behaviour of the tourists/residents is one of the most indeterminate. In fact, it concerns phenomena relating to vandalism, waste production, abandonment and management, encouraging the permanence of birds and improper use of the city, its spaces and its monuments.
Finally, the phenomena of erosion of the canals caused by the increasing swell due to the growing number of craft used for urban transport, the presence of taxis and other means of transport for people, materials and supplies and the transit in St Mark’s basin of large cruise ships, was assessed. Many studies have already been carried out on such phenomena and have provided a considerable amount of information.
This phase of research therefore led to the collection of a huge amount of analyses, data, studies and scientific publications regarding the phenomena

in question carried out over the last decade.
Such publications were organized into a thematic register that offers the opportunity to quickly find information that would otherwise be lost or difficult to consult.
Systematization of the information acquired permitted the creation of a general picture of the complex phenomena involved - broken down into macro phenomena, phenomena and micro phenomena - and made it possible to explain the interaction that exists between the previously described phenomena at various levels (Tab. 1).
On the basis of such analysis, it was possible to identify a method for describing and representing the dynamics of urban transformation underway, capable of linking in a systemic manner a considerable quantity of data that was originally disaggregated.
This permitted the development of both diachronic and synchronic analysis of the phenomena and permitted its reinterpretation with the theme of wear as key.
Relationships between the phenomena, on both a macro and micro scale, have been read starting from the factors of risk that can be generated by

MACRO PHENOMENON	PHENOMENON	MICRO PHENOMENON
Transformation of urban system	Changes in use framework of the city	Change in the composition of the permanent population
		Abandonment of flat/depopulation
		Change the percentage ratio between residences and commercial and business structures
		Change the type of commercial offer and merchandise
		Variations in the typological structure of space for renewal
		Widespread of licenses of the so-called "plateatici"
	Transformations linked to the tourism phenomenon	Change in the number of tourist flows
		Change the cultural offer in the city
		Concentration of presences in urban places
		Presence of preferential urban path
		Change in the quantity of waste products
	Changes in the urban maintenance's service	Change of number and type of maintenance activities on surfaces
		Change of number and type of maintenance activities on surfaces by private citizen
	Changes linked to the tidal cycles	Variations in the use of public space
		Variations in the use of private space below sea level
Transformation of system of canal	Changes in use framework of the city	Change in the number of vessels for transporting goods
		Change in the number of private vessels
		Change in the number of vessels for transporting waste products
		Changes in regulation of the use of the canals
		Changes in regulation of the use of the shores and docks
	Transformations linked to the tourism phenomenon	Percentage change in the number and type of vessels
		Change in number and frequency of berthing to meet the demand for mobility
	Changes in the urban maintenance's service	Change in the number and type of maintenance activities of the shores
		Change in the number and type of maintenance activities of the canals
		Changes in the method of substitution of poles and so called "bricole"
	Changes linked to the tidal cycles	Variations in the ordinary use of the canals
		Changes in the dynamics of water movement
Transformation of ecosystem	Changes in use framework of the city	Change in the amount of pollutants dissolved in water due to the transportation system
		Change in the amount of pollutants released into the air due to the transportation system
		Change in the amount of pollutants dissolved in water due to the accommodation system
		Variation in the type and intensity of smells
		Change in the amount of waste produced
	Transformations linked to the tourism phenomenon	Change in the amount of waste produced and abandoned in the city
		Changes in the quantity and composition of species of birds (pigeons, seagulls)
	Changes linked to the tidal cycles	Changes in the composition of marine flora. Possible stagnant waste water due to sewage system



Tab. 1: Matrix of the links between phenomena on a macro and micro scale. Correlations between phenomena (gray squares) may generate or increase wear processes. The sum of different correlations also produces wear dynamics reported in Fig.1

tourism pressure, from the characteristics of the production system and from anthropic action and have been grouped together in areas linked to physical-type wear and perceptive-type wear.
These complex relationships are shown in Fig.1.

3. Research developments

On the basis of the data and elaborations briefly illustrated here, it was deemed indispensable to proceed to completion of the construction of a reference framework by identifying further parameters that could prove useful in describing the processes of wear that interest the site. In particular, attention will focus on the repercussions on a perceptive level of urban transformations.
The second objective is experimentation of the analysis model for the factors of wear, identifying one or more areas as a case study.
Finally, the outcome of research should permit the identification of some tools and scenarios of intervention aimed at mitigating the processes of both physical and perceptive wear.
The study method provided develops based on a waterfall procedure, with consequential phases and moments of recursive assessment. In general, the flow of activities can be summarized as follows:
- clarification of the reference framework in order to:
    - analyse the factors of risk;
    - identify the physical and socio-cultural dynamics, as well as the connections and systemic interrelations that determine the processes of wear, at various levels of intensity;
- identification of the measurable parameters and the significant critical issues

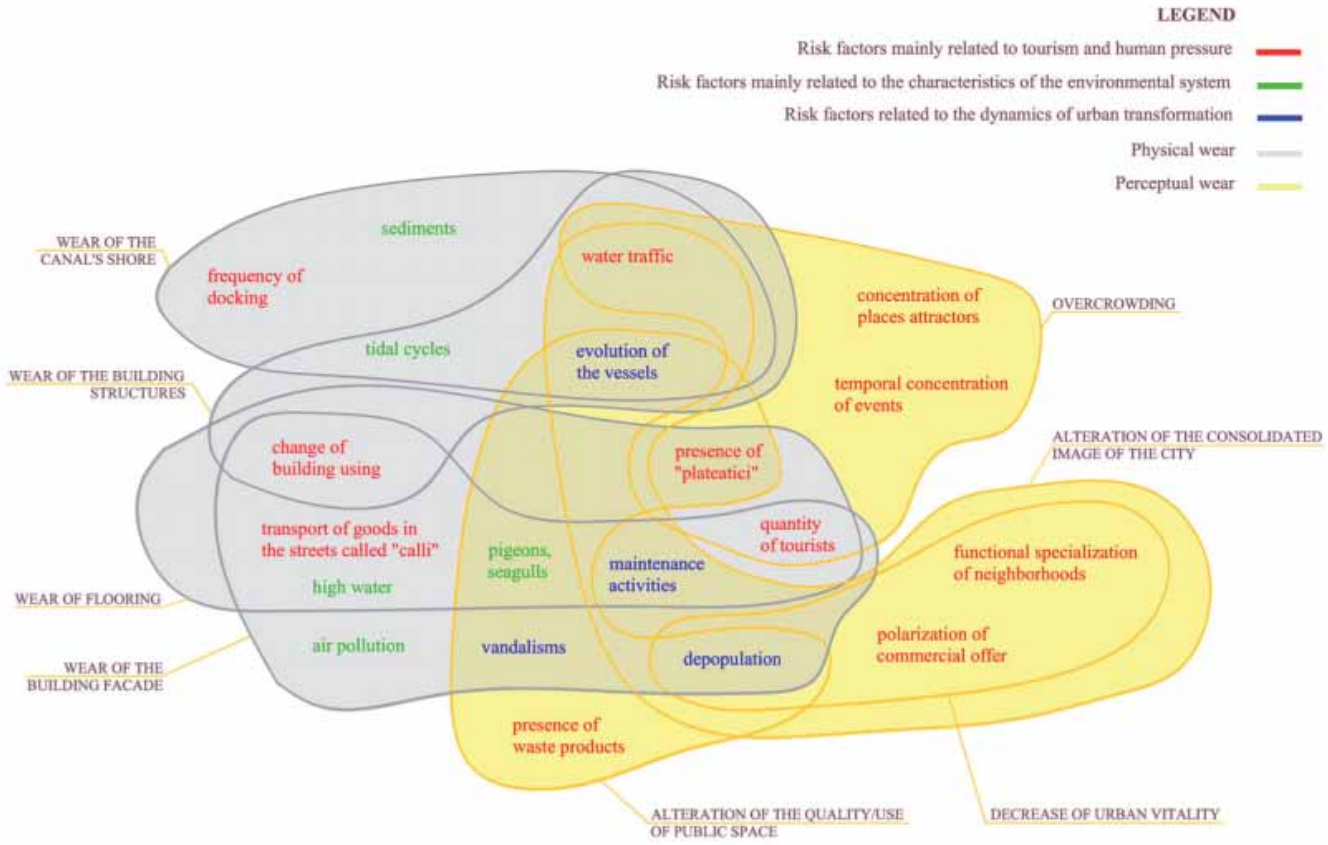


Fig.1 - Diagram of the relationships between the phenomena that represent factors of risk and the processes of wear caused by them

for interpreting the effects of wear;
- definition of the tools and criteria for measuring the phenomena of wear;
- preliminary definition of mitigation actions based on the systemic interpretation of the phenomena;
- experimental application of the method following identification of one of more case studies; it will thus be possible to:
    - quantitatively measure some of the processes of wear described;
    - check the pertinence of the indicators previously identified and the correctness of the study process;
- confirmation or updating of the indicators for periodic monitoring and mitigation tools/actions;
- long-term assessment of the effectiveness of mitigation strategies.

Given the fame and visibility the city of Venice enjoys, it would undoubtedly represent an emblematic case for the experimentation of models for the analysis of wear processes directly or indirectly linked to the presence of mass tourism. The method elaborated and experimented for the case of Venice could therefore, become a pilot case to export to other art cities or sites of cultural interest subject to heavy anthropic pressure, even though the type and intensity of the phenomena recorded in the case in question are closely linked to the peculiarity of the settlement system in the old town of Venice. Proposing the operational criteria used for the case of Venice in different contexts would therefore, require adaptation to the specific characteristics of the different application environments, but would nevertheless guarantee the effectiveness of the general methodological approach.

Notes

[1] Municipality of Venice, *Management Plan 2012-2018. Venice and its Lagoon* - UNESCO World Heritage Site.

[2] The existence of a close link between tourism and the environment, intended in its broadest sense, including social and economic aspects as well as natural ones, is now a fact that has been fully demonstrated and is generally accepted. Indeed, the particular characteristics of a site, specifically its distinctive features and the layout of the natural environment, often constitute one of the main factors that attract tourist flows to a specific site. Likewise, the delicate balances of the ecosystem represent one of the areas of greater vulnerability of a territory, if the tourist phenomenon is not adequately controlled and governed. In this respect, there is a vast amount of literature on the theme that identifies the various types of impact that tourism can generate in the destination sites. In general, these studies highlight how the pressure of tourist flows, as well as influences the processes of economic growth and the level of wealth in financial terms also has repercussions on the social and environmental context that are not always positive. Therefore, there is a need to reflect in some depth on the criteria of tourism management, in an attempt to identify new methods of assessing the impacts determined by this on the socio-economic and environmental system and to be accountable to the principles and criteria that inform the concepts of sustainable development and of sustainable tourism [cf. Pazienza P., Vecchione V. (2006), *Stima della capacità di carico dei flussi turistici nel Parco del Gargano*. Quaderno no. 19/2006, D.S.E.M.S. University of Foggia].

[3] The report by ICOMOS on the state of the preservation of the site (2006) highlighted the need to adopt mitigation actions in relation to the anthropic pressure linked to tourist flows, the depopulation of the city centre and variations in water levels.
[4] For example, the “Magistrato delle Acque” with regard to the defence of the phenomenon of high tide, Insula S.p.A. with regard to management of urban maintenance and Coses, a publicly-owned Venetian research consortium no longer active since early 2012, with regard to the theme of tourism and the dynamics of development of the city. As well as these bodies, without doubt worthy of note is the research and initiatives carried out by the Municipality of Venice, the Architectural and Landscape Heritage Department of Venice and its Lagoon and the universities, as well as individual researchers that have been collaborating with the local administration for years in the study of certain specific themes.
[5] More specifically, by risk we mean the result of the combination of environmental danger and the vulnerability of the building (or urban system) to exposure. Risk is the measurement of the level of damage that, on the basis of the characteristics of danger (climatic, hydrogeological, seismic or anthropic) of the site and the conditions of vulnerability of the elements exposed (conditions of decay, resistance to seismic activity, quality and quantity) can be verified in a given period of time.
Danger is the probability that a given natural phenomena might occur in a specific period of time or the combination of conditions of environmental or anthropic aggression that a building system is subjected to and that interact with it, causing more or less rapid phenomena of decay.
Vulnerability is the propensity of any element (for example, buildings, architectural and archaeological artefacts, urban systems) to be damaged or decay due to one or more external agents connected to the conditions of environmental and anthropic danger. Vulnerability represents an intrinsic characteristic of the exposed element, is directly dependent on its conditions of decay or its state and relates the action (environmental/anthropic aggression, earthquake, etc.) to the damage the action itself may cause.
By exposure we mean the quantity and quality of the assets exposed to a specific natural or anthropic phenomenon (meteorological, hydrogeological, seismic, decay, etc.).
[6] Outlining of the geographical area considered is in any case variable based on the phenomenon being mapped each time: for example, it will be broader for analysis of the transport system and the network of privileged tourism itineraries, narrower for assessment of the effective use of urban spaces by the various categories of users.
[7] Physical-mechanical wear type, attributable to material decay, is associated with phenomena caused by anthropic pressure, colonizing animals, erosion caused by swell and atmospheric conditions: we highlight the opportunity to specify each phenomenon attributable to the above-mentioned macro-causes and also add the numerous phenomena caused by natural deterioration due to age, as defined in UNI 11182:2006 standard.
[8] Wear associated to the question of perception explains some of the phenomena that negatively influence monumental and landscape protection. In particular, reference can be made to the overcrowding of topical sites (some images of the Marciana area during the Carnival period are emblematic), the effects of the production of waste or vandalism that jeopardize the fruition of the urban landscape or the single monument. This category could also include cases of recent intervention on buildings in the lagoon area, particularly relating to the external surfaces of the buildings. Such interventions could be considered an effect of “wear” because they neither take into account the construction features that need to be preserved because they characterize a historical urban whole nor methods of material decay, respecting exclusive objectives of

reestablishing a certain idea of decorum, often disregarded after a few months due to the effects of accelerated decay of a pathological nature. It could be objected that such cases of wear should be considered natural deterioration, related to the effects of agents of decay of a physical-mechanical nature with reference, in particular, to the basement parts of the external surfaces, but such phenomena are largely attributable to the realization techniques and type of materials used, generating material decay that is unusual for Venice and that jeopardizes “correct” perception of the building heritage. [9] The theme of wear deriving from processes of urban transformation could also be extended to the transformation of single buildings. In this way, all the processes of immaterial wear that generate loss of identity in both external spaces (stallages, plots for traders, transformation of the types of commercial offer, loss of usability due to overcrowding or saturation of the itineraries, effects of demographic trends, etc.) and individual buildings (conversion of use of the ground floor, formation of services supporting accommodation functions, conversion into use as B&Bs and hotels, etc.) would be defined. We should specify that the theme of site overcrowding and saturation of itineraries can be intended both in terms of perceptive wear (jeopardizing fruition of the monument or site) and wear deriving from the processes of transformation (jeopardizing the possibility of fluid transit or accessibility to a given site).

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