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Presence, Absence, Transience: The Spatiotemporalities of Sand

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Abstract: Sand grains are ubiquitous in the Earth's system, and are found in different environmental settings globally, but sand itself as a physical object has multiple conflicting meanings with respect to both its agglomeration into landforms such as sand dunes and beaches, and how sand and its dynamics have cultural significance and meaning. This study takes a transdisciplinary approach towards examining the multiple meanings of sand, focusing on sand as a spatiotemporal pheneomenon that exists in different contexts within the Earth system. The nature and spatiotemporalities of sand are framed in this study through the concepts of presence, absence and transience, which are key interpretive approaches that lie at the interface of how the physical and phenomenological worlds interact with each other. This is a new and innovative approach to understanding people–environment relationships. These concepts are then discussed using the examples of the dynamics of and values ascribed to desert dune and sandy beach landscapes, drawn from locations globally. These examples show that the dynamic geomorphic changes taking place in sand landscapes (sandscapes) by erosion and deposition (determining the presence and absence of sand in such landscapes) pose challenges for the ways in which people make sense of, locate, interact with and value these landscapes. This uncertainty that arises from constant change (the transience of sandscapes) highlights the multiple meanings that sandscapes can hold, and this represents the comforting yet also unsettling nature of sand, as a vivid symbol of human–Earth relationships.

Keywords: beaches; cultural significance; deserts; dunes; quartz; sandscapes

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1. Introduction

The Earth system and human worlds often operate over distinctively different spatial and temporal scales [1,2] and this can result in a mismatch between the perception and actuality of the workings of Earth's physical processes and the landforms that are associated with them, and how these physical phenomena intersect with the human world [3]. The perceptual framing of elements of the physical world, such as landforms and their attributes, have implications for their apparent rarity/commonness, spectacle, beauty, value, function, and dynamics (e.g., [4–7]). A limitation of these approaches is that they do not explore in detail what it is about the properties of the physical world that can engender these different perceptions, meanings and interpretations [8]. The pivotal analysis by Lowenthal [9] highlights the milieu of individual experience, world views and imagination in the construction of personal geographies and the relationship of the individual to their surrounding world(s). More recent work refines the concept of landscape and relations between people, space and place (e.g., [1,10,11]), especially along coasts that can be considered as liminal spaces located at the boundaries between different environmental worlds [11,12]. However, landscapes are a composite expression of different landforms, processes and anthropogenic imprints, and this means it is difficult to explore relations between single landscape elements and lived human experiences and interactions [8,11].

This study proposes a different and innovative conceptual viewpoint of capturing the physical world, by considering the physical properties, dynamics and significance of a specific but pervasive element of global landscapes, namely sand. Sand, like other ubiquitous Earth resources such as air and water, is conceptually complex in the

ways in which people (as individuals and as wider society) perceive and make sense of it [13,14]. Several studies have described how sandy beaches can be viewed and appreciated from different users' perspectives [15–18], but where the role of sand is implicit rather than explicit; where sand merely represents a passive substrate rather than as a site of engagement and interaction [19]. However, the multiple and nuanced relationships that exist between sand and society have been noted in different physical contexts, such as coasts, deserts and rivers (e.g., [12,14,20–22]), although these have not been fully explored.

This study focuses on the spatiotemporalities of sand that exist in desert and coastal environment, exploring the nature of the interconnections between sand and society in these places. The purpose of this paper is to (1) consider how the interlinked conceptual approaches of presence, absence and transience can help explain the physical dynamics taking place in sand landscapes (sandscapes); and then apply these approaches to (2) discuss the properties and dynamics of desert and beach environments and how these sandscapes influence human values and meanings, and from different perspectives. This approach can also apply to sandy riverscapes and lake environments.

2. Sand in the Earth System

Sand grains are found in many different environments globally, including deserts and coasts, rivers and lakes, the soil and the continental shelves [23,24] (Figure 1). The term 'sand' refers to a specific particle size, in the *b*- (intermediate) axis range 0.0625 µm to 2000 µm (2 mm) [25], and does not refer to a specific shape, composition or any other property of the particle. However, the most common sand mineral is quartz, which is present in all rock types and is released along with other mineral grains to the surrounding environment by weathering. Quartz is chemically stable, resistant and thus able to potentially survive in the landscape for a long period of time. Once they have been detached by weathering, loose sand grains can be transported and deposited by water and wind, mediated by global climate and human activity. It is estimated that around 7.5×10^{18} sand grains exist globally [26], equivalent to around 7.5 billion grains, or 14 tonnes, for every person on Earth. The basis for this is that, assuming individual sand grains are 1 mm in diameter (very coarse sand) and that these are stacked against each other in regular rows and columns (in reality this is not the case, as they will stack within grain interstices, like eggs in an egg-box), there are 1×10^9 grains per m^3. Quartz has a typical density of 2.65 g cm^3 (2.65 t m^3), but assuming an average porosity of 30% within a sand body due to grain packing, this means a mass of sand of 1.855 t m^3 × 7.5 m^3 per person = a total mass of 13.9125 t per person. This assumes a global population of 8 billion people. Welland ([27] p. 72) uses a number of sand grains "larger or smaller than 10^{22}" which yields a value of 1250 m^3 or 2318.75 t per person, using the same assumptions as given above.

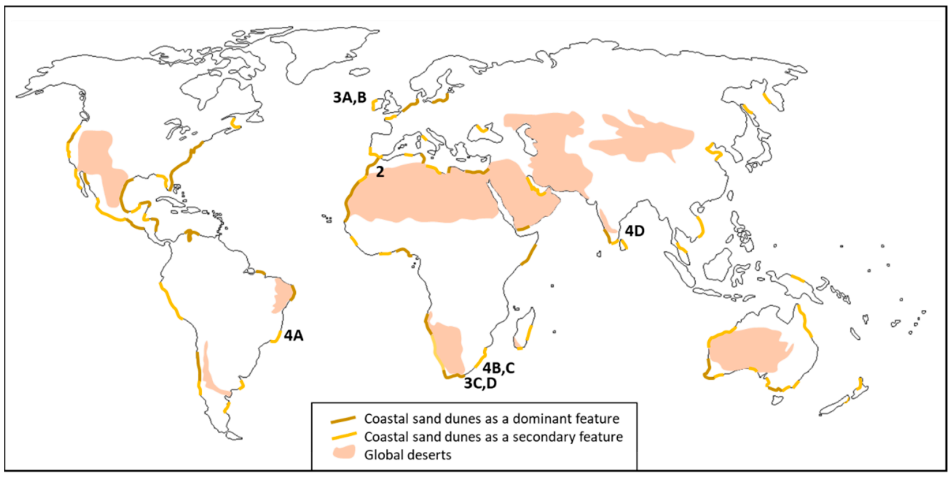

Figure 1. The locations of coastal sand dunes [28] and deserts at a global scale [29], and the locations of Figures 2–4 (bold).

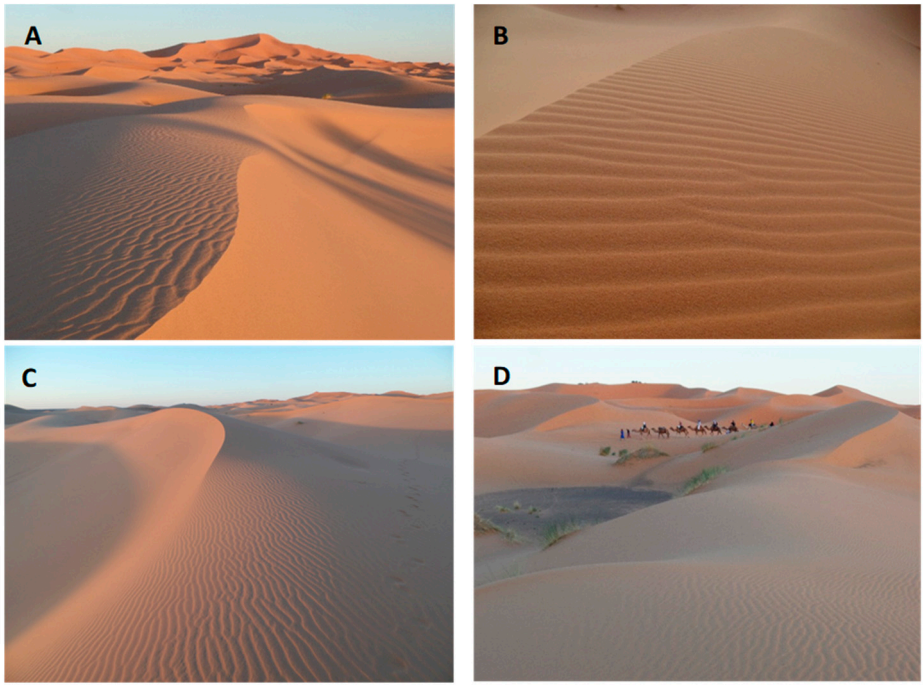

Figure 2. Examples of sand in desert dune systems on the western periphery of the Sahara desert in western Morocco. (**A**–**C**) Migrating draa and superimposed ripples, showing how these landforms on different scales are superimposed upon and move at different rates and directions, (**D**) camel train within the dune system, whereby the human world negotiates the obstacles and opportunities presented to them by the migrating dunes (photos: author).

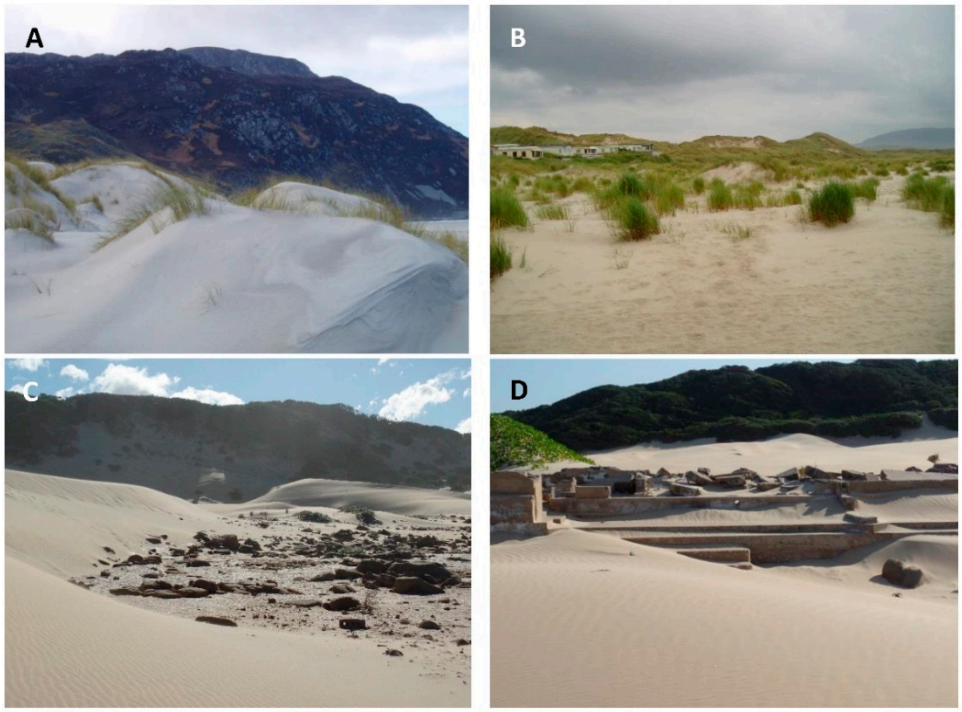

Figure 3. Examples of sand within beach systems. (**A**) Embryo and (**B**) vegetated dunes in the supratidal zone, northwest Ireland; (**C**) oblique dunes migrating over a deflated interdune hollow and (**D**) migrating sand sheets variously burying and then exhuming the foundations of a former beach house, both at Eastern Cape coast, South Africa (photos: author).

Figure 4. Examples of people–beach interactions and different types of activities supported in beach spaces. (**A**) Rio de Janeiro, Brazil; (**B**) Durban, South Africa; (**C**) St Lucia, South Africa; (**D**) Chennai, India (photos: author).

Their ubiquity means that sand grains themselves are not diagnostic of any one particular location, environment or process. This means they can be considered as timeless and placeless entities and their macroscale expression in the landscape may conceal their evolutionary history. Bendiner-Viani [7] described how understanding the local can help us understand the global and this (although referring to the urban environment) provides a parallel for the ubiquity yet also the banality of sand as an undercurrent of the everyday.

Furthermore, the word 'sand' describes both individual sand grains, and also larger sediment bodies such as dunes that may contain many billions of grains. This ambiguity means that qualifiers such as 'grain' or 'dune' are useful in locating sand in space because they allude to the scale of the entity in question. Sand forms some the world's biggest landforms, such as the Rub' al Khali sand sea in the Saudi Arabian peninsula, which covers 560,000 km^2, but also some of the smallest, such as a single ripple on a beach that may be less than a centimeter high and a few tens of cm long. A microscope can reveal the size, shape and micromorphological characteristics of sand grains, which can inform on both their origins and their transport and diagenetic histories (e.g., [30,31]). Micromorphological studies of dune and beach sand provide a narrative of the journey of sand grains, their ages, environments of deposition, and how they have responded to climate changes [31,32]. Thus, there is a microscale history of sand grains that is hidden to the naked eye, a secret message from the past.

This ambiguity of meaning and spatial scale of sand is significant (e.g., [33]), because it highlights its hidden ubiquity and its intersection with the human world: a sand grain is small enough to be unnoticed but big enough to be felt in your shoe. The world is indeed made of sand (e.g., [3,27]). Sand is everywhere, yet is unseen, corresponding to Sartre's 'nowhere, but everywhere' [34]. It is present in the built environment in the formation of concrete, and is contained in the soil, regolith and made ground, and sand mining represents a global trade network worth USD1.71 billion in 2016 [35]. Thus, sand is a pervasive part of the human and physical worlds and has multiple identities. This highlights the locational ambiguity of sand in the environment: on the surface, in the

subsurface, in water, in soil, in the air; in pure form on a beach or as mixed with other materials in soil or in the built environment.

3. Making Sense of Sand: Presence, Absence, Transience

The concepts of presence, absence and transience can be used to interpret the meanings and dynamics of sand, their relationships to human activity and the values ascribed to sand in different settings. This consideration is inspired by work in death and memorialization studies in which the physical and emotional presence and/or absence of different material and non-material entities within the landscape engage with human actions and values in different ways (e.g., [34,36–38]).

3.1. Presence and Absence

The concept of presence and absence can help identify the ways in which sand can be viewed as an entity, as either individual grains or aggregated as landforms. The landscape-based approach to presence and absence has been considered in several studies (e.g., [39,40]). Here, human engagement with the landscape, its topography, properties and dynamics, is undertaken through a longitudinal narrative in which identity and memory are forefront, providing a biography of place, and viewing landscapes as both physical and cultural palimpsests [18,33,34,38,41]. These studies demonstrate the duality of both being grounded in the specific and microscale context of time and place, yet also referring to the universal, the timelessness and placelessness of human memory, emotions and landscape psychospaces [19,42,43]. This echoes Massey's [33] ch. 12 discussion on the here and now, the coming-together of space and time. Thus, sand landscapes (sandscapes) can be viewed as shifting, changeable entities that are both banal and monotonous, and unpredictable, dangerous and suffocating [12,19].

Relationships between presence and absence of sand can be conceptually approached from three different interpretative viewpoints. (1) Presence, absence. This views one state being successively replaced by the next; therefore presence and absence have spatial and temporal dimensions because they operate over space and time. Changes in sand depth and thus geomorphic expression take place by sediment burying (by deposition) or exhuming (by erosion) the underlying surface, typical of migrating sand dunes in desert or coastal environments or by systematic sand spread by wind or desertification. Here, sand presence or absence is viewed in terms of its depth and lateral extent as mapped 3D bodies. The migration of sand bodies such as dunes has agency in variously concealing or revealing evidence of human occupation, values and identity. (2) Presence–absence. This views presence and absence as a continuum, with sand being ubiquitous but varying spatially and temporally in its properties. Ideas of presence–absence as a continuum have implications for the position and meaning of borders and boundaries [11,44], demarcating landforms such as the size, shape and position of sand dunes, and thus the three-dimensionality of sand bodies, both surface and subsurface [45]. (3) Presence/absence. This views sand as a quantum entity that is both present and absent, seen and unseen at the same time, within any one landscape consistent with the Copenhagen Interpretation of quantum mechanics [46]. This viewpoint is also consistent with the scale-invariance of sand, occurring in the Earth system over a range of spatial and temporal scales (e.g., [47]); and consistent with the multiple ways in which sand exists in both the natural and built environments.

3.2. Transience

Understanding the duality of presence and absence of sand can be informed by ideas of transience. Transience refers to impermanence and mobility, the property of continual or punctuated change. Transience in landscapes arises when geomorphic processes operate, and thus has a spatial and temporal expression where it corresponds to those processes that are in action at any one place/time [48]. Transience is manifested by the development of landscape palimpsests, where landform and sediment patterns are not in equilibrium with prevailing environmental or climatic forcing [49,50]. This can help explain why

landforms may persist in the landscape as relict features, out of sync with environmental regimes. Sediment systems at a landscape scale on slopes, rivers and coastlines may also show disequilibrium with climate forcing [51], and this is a problem when trying to understand the nature of present landscape change where direct human activity—as well as climate change—are influencing these sediment systems [52]. Studies on the transient behaviour of desert environments highlight the ways in which land surface properties (vegetation, surface boulder cover) can impact on the sensitivity of these landscapes to climate forcing [50,53–55].

Transience also refers to uncertainty, how observers make sense of change that take place within landscapes [12,44,56]. This viewpoint of transience both mourns, celebrates and memorializes the past [36,38,39,57], and takes note of difference, change and absence that emerge over time [58,59].

This evidence suggests that sand has an uneasy relationship to the human experience, shaped by ideas of memory and loss that can be interpreted through the lenses of presence, absence and transience. This can be examined in detail by considering specific types of sandscapes and their properties and dynamics.

4. The Meaning and Interpretation of Sand: Examples from Different Contexts

Human activity can cause the direct physical transformation of sand landforms by mining, engineering and land use change; and human interactions with these landscapes in different ways are influenced by and also impart cultural meanings and significance [14]. The dynamic nature of sandscapes also poses challenges to human perceptions of environmental stability and change (e.g., [60]). In order to examine these interrelationships, the properties, dynamics and human interactions of desert dunes and sandy beaches are now described.

4.1. Desert Sand Dunes

Although desert (arid) environments such as the Sahara Desert are often covered by loose sand, large-scale sand seas (ergs) with interconnected migrating dunes cover only 22% of the Sahara [61], and these provide significant local relief and complexity (Figure 2). Dunes of different sizes and types may also be superimposed on one another (Figure 2A,B), meaning that individual dunes are often not well delineated. Several studies have examined the migration patterns of free dunes across Saharan ergs [62,63] and Rub' Al Khali [64] and these highlight the high spatial and temporal variability of dune migration rates and thus changes in desert landscape geographies. Dune migration can lead to elements of the human environment becoming variously buried or uncovered by sand [65] (Figure 2C). This can in turn change the relationship between desert landscapes and their inhabitants and, thus, the preserved spatial expression of human activity and cultures in deserts and their oral histories [66,67].

Studies of desert environments and peoples have most commonly been framed by a western colonial gaze, in which sand seas such as in the Sahara or Arabian peninsula represent a liminal, hostile, featureless place where the norms of scale, direction and navigation cease to apply, and where *mirages* of desert geographies can be manipulated [68]. The explorer Wilfred Thesiger [69] p. 3 described his transit of the Empty Quarter of the Rub' Al Khali, with his guides "lost and bewildered among these great dunes, unable to distinguish one from the other". To desert dwellers, however, these are landscapes replete with history, symbolism and cultural significance, with the sound of wind, observations of the tracks of animals and migrating sand dunes (Figure 2D), and smell of water and vegetation (near oases) and the sight of incoming sand storms at the front of a haboob wind representing important touchstones of desert–human relations. For example, the sound of booming, whistling or singing sands caused by sand avalanches down a dune face has been extensively noted by desert travellers [70], and has significant cultural significance through oral histories and mythology (see [71] (pp. 261–339) [72,73]). These highlight the mystery and power of the desert, and its changeability.

4.2. Sandy Beaches

Unlike desert ergs, sandy beaches are usually clearly spatially defined, controlled by the cycles of tides that shrink and expand beach width, and with long-term beach dynamics controlled by tides, waves, wind and human modification. As such, many sandy beaches can be considered as compartmentalized systems that are geomorphically isolated from the areas surrounding them (Figure 3). Beaches are also affected by the growth and migration of sand dunes at their landward side [74] which, especially when vegetated, blurs the boundary between land and coast, the permanent and the transient (Figure 3A–C). A recent overview study showed that worldwide coastal sand dunes show a trend towards increasing stabilization (thus decreased dynamic behaviour), attributed to increased vegetation cover and urban development [75]. The scenic attributes of sandy beaches have been examined from the perspectives of different users or with respect to different management priorities and practices (e.g., [16,76,77]). There has been less emphasis, however, on how people interact with each other and with the beach landscape (Figure 4A), and the role of sandy beaches as experiential and performative spaces [12,15,19,20,78] (Figure 4B–D).

Coastal erosion can be considered as a metaphor for human–environment relations, especially in the Anthropocene, with the changing geography of coastlines seen as an outcome of physical processes encroaching upon the human world [79,80]. Several different narratives exist that describe human relationships to changing sandy coastlines [22,81]. These include reclaiming 'lost' space as an expression of power and ownership [21], sand as a representation of time and temporality [12], and weather conditions in shaping the nature and style of human engagement with beaches [78,82]. Preston-Whyte [83] described the multisensory experiences of surfers on a sandy South African beach, and how issues of identity and exclusion arise based on their use of the beach space and their 'reading' of environmental conditions, such as wave state. Likewise, anthropogenic coastlines nourished by sand pumping from offshore or modified by groynes, revetments and other structures provide a buffer for coastal erosion and new space for people and sand migration [84,85]. These geoengineered coasts shape and manipulate human–environment relations by the creation of relief and new habitats. Sandy beaches are thus increasingly commodified and regulated human spaces [86] (Figure 4).

5. Discussion

Sand's unique properties poses challenges of interpretation of human–environment relations. In one sense, the ubiquity of sand conceals its diversity and multiple meanings [15] by being both visible and invisible, present and absent, and through the ways in which it is associated with human memory and meaning [18]. However, the varying scales at which sand exists, and its transience and dynamics in the landscape, are unsettling properties that question the meanings and interpretation of sand.

5.1. Interpreting Sand through a Human Lens

The conceptual framework of presence, absence and transience can help explain relationships between sand and human values, perceptions and experience [18,19,87]. In a sand timer, the inevitable passage of time is recorded as each grain slips past. Sand movement buries past landscapes (Figure 3C,D). It represents the forces of nature subsuming human activity, values and memory; and the abandonment and decay of evidence for human life as sand smothers the landscape [58,88]. Evidence from archaeological and abandoned landscapes shows the ingress of the earth into human spaces, An example is the USA 'dust bowl' of the 1930s in which abandoned homesteads were slowly subsumed into the physical landscape by the spread of sand, dust and soil [89–91]. Similar examples today are by desertification, the spread of desert dunes into abandoned agricultural fields. DeSilvey [58,88] described how human cultural and personal artefacts, abandoned in such marginal environments as midwest USA by the drift of sand and dust, provide touchstones of human memory, sense of place and identity. Uekötter [91] discussed the multiple cultural

narratives that exist on the dust bowl, and the diverse actors involved. On sandy coasts, the abandonment or erosion of built structures reflects both a change in human use and values, and also reclamation of the beach space by sand drift (Figure 3D).

Several different cultural landscapes that bear material and non-material evidence for human use and memory have been examined from the viewpoint of how changes in the physical landscape imprint on cultural heritage and memorialization. For example, mining landscapes demonstrate the impacts on the physical landscape of human exploitation of natural resources. Mining thus creates new anthropogenic landscapes, but these also symbolize the hegemony of human power over nature, the exploitation of human labour, and as places of destruction, death, pollution and desecration of the natural world [38,92]. Similarly, sand reflects memory and loss; the sands of time flow irrevocably forward. This memory of sandscapes is based on both mourning of the past, the erosive power of nature and loss of land and built structures by coastline retreat; yet also providing comfort in the transient remembrance of the touch, sound, smell and sense of sand, beaches and dunes [19,20,43] (Figure 5).

Figure 5. Montage of childhood photos: the author, sand, and family memories (photos: author).

5.2. The Life-Ways of Sand

Sandscapes can be considered as liminal spaces in which the spatial markers and symbols of human activity become confused, blurred or indistinct [44,87]. This arises in part through the changing geography of sandscapes caused by dune migration and sand erosion/deposition [12]. One way of reconciling human values and identity with sandscape dynamics is through Lefebvre's [93] rhythmanalysis, in which the life-modes of the physical environment and physical–human relationships intersect with one another [94,95]. Rhythmanalysis emphasizes the tempos of change that take place in the real world, in particular the everyday, the banal and the life-ways of people that are set in an environment that contains a topography, fixity and meaning. In sandscapes, this rhythmanalysis responds to the distinctive tempos of waves, wind and tides on a beach, events such as storms, and the periodicity of days and seasons. Although this rhythmicity of sandscapes demonstrates their ever-changing nature, it also provides a comforting heartbeat and inti-

macy that is embedded in the everyday practices of sandscape users [19,96,97]. Such an approach demonstrates the tactile, experienced intimacy of people and the environment, of fleeting sensations, and the evocation of memory, loss and also hope [44,95,98]. Sand's ability to cross scales of time and space means it has multiple layered and conflicting and mutable meanings, from the delight of building sand castles on a beach (e.g., Figure 5), to the suffocating experience of a sandstorm [72]. From this perspective, rhythmanalysis is a potentially important future research direction because it can focus in on the temporality of presence, absence and transience within sandscapes, as well as the rhythmic (ritualistic) behaviours of sandscape users.

5.3. Landscape Change in the Anthropocene

The transformation of the physical environment, on a global scale, by human activity in the Anthropocene highlights that the distinction between the physical and human worlds is becoming ever more blurred [99–101]. Thus, geoengineering, land use change, urbanization and environmental resource exploitation have implications for the natural process regimes and rates of land surface and ecological change that have (historically) made regional landscapes distinctive [52]. Globalization of socioeconomic and cultural activities, including communication tools, also impacts on how people experience, value and interact with the physical world, including virtually. With respect to sandy coasts, this may change the types of human activities taking place there, their spatiotemporal patterns, and how coastlines are perceived as lines of resistance against ongoing climate change [102,103]. Progressive and sustained coastal erosion along some global coastlines in the Anthropocene also yields a sense of the inevitability of loss, an erasure of the past, a melancholy [79], but this is not yet fully understood. This is not unique to sandscapes, however, and equally applies to the loss of nature and the natural world more generally [104].

6. Conclusions

The pervasive nature of sand, as a fundamental part of the Earth system, represents something that is inimical both to the Earth and to the human experience. The presence of sand as a construction material has built the human world on a global scale. Sandscapes are, however, sensitive to climate and environmental disturbance as by coastal erosion. The examples of desert dune and sandy beach landscapes show the dynamic yet also fragile nature of the physical environment, and that the unseen force of sand migration brings into focus evidence for presence, absence and transience. They pose questions of time and materiality; how footprints are erased by the tide, how migrating sand dunes blanket agricultural fields under desertification, how the 'dust bowl' spread into abandoned homes. They evidence the uneasy dialogue of the physical and human worlds.

Transience and impermanency in the physical world more generally, such as by catastrophic events, pose a crisis for human culture, history and value systems, as well as for more practical purposes such as environmental and heritage management. This is particularly important in sandscapes such as Saharan sand seas, where dune landscapes may be protected as part of World Heritage or Ramsar Sites, but where there is a lack of understanding as to how climate change and dune migration may impact on site integrity and its cultural, ecological and geomorphic values [65,105]. The environmental/cultural relationships of sand, as for water and air, are not well understood, and this is an important future research priority, framed in the context of the dynamics of physical processes in the landscape as well as climate change.

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