AN INVESTIGATION INTO THE METHODS USED TO MEASURE CULTURAL ECOSYSTEM SERVICES ASSOCIATED WITH COASTAL WETLANDS

By

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DECLERATION

I certify that this thesis:

1. does not incorporate without acknowledgement of any material previously submitted for a degree or diploma in any university
2. and the research within will not be submitted for any other future degree or diploma without the permission of Flinders University; and
3. to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed: PM Mkukumira

Date: 28th October 2024

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Abstract

Coastal wetlands are among the most threatened and stressed natural ecosystems in the world despite providing various benefits to humans. Culture can play an important role in protecting wetlands from loss if it is well represented in the assessment of ecosystem services (ES). ES, which are defined as benefits people obtain from ecosystem, are classified into provisioning, regulating, cultural and supporting services. Cultural Ecosystem Services (CES) are services that nature provides to support a range of life-enriching and life-affirming benefits to humans. The CES concept provides a cultural dimension of ES. Unlike other ES, CES are difficult to measure because of their non-material and intangible attributes and their valuation is subjective as it depends on one's perception and experience. Close linkages among CES categories further complicates CES valuation as it may result in double-counting. Consequently, the value of CES is not well captured in the assessment of ecosystem services. This study aims at understanding how culture is measured by investigating and analyzing methods used to measure CES. A systematic literature review was used to collect information on CES valuation. After searching and screening relevant articles, a total of 31 research articles were identified as the most relevant to this study. The review identified 9 valuation methods that were used to measure 10 categories of CES. The results of the review showed that non-monetary methods, especially survey questionnaires, were the commonly used valuation methods. It was also observed that recreational services and aesthetic values were the most frequently researched CES categories. However, CES represent a package of all cultural services that are dependent on each other. Therefore, to adequately represent CES in ES assessment, it was recommended that CES should be measured as a bundle of services not just one or two CES. Additionally, combining monetary and non-monetary methods may potentially capture a more accurate value of CES.

Keywords: Coastal wetlands, ecosystem services, cultural ecosystem services, monetary methods, non-monetary methods

1. Introduction

Coastal wetlands are complex social-ecological systems comprising of mangroves, seagrasses, and salt marshes. According to Kennedy et al (2014, p. 6), coastal wetlands' boundaries "may extend to the landward extent of tidal inundation and may extend seaward to the maximum depth of vascular plant vegetation". In terms of their coverage globally, the combined cover of all coastal wetlands comprises of approximately 49 million hectares of land and provides a diverse array of socio-economic and ecological benefits to the coastal population (Pendleton et al., 2012). Despite their importance, coastal wetlands are among the most threatened and stressed natural systems in the world (Good et al., 1999; Navarro & Rodríguez-Santalla, 2023). About 8,000km^2 of coastal wetlands are lost every year and it is projected that 30-40% of tidal marshes and seagrasses, and nearly 100% of mangroves could be lost in the next 100 years if the current loss rate continues (Pendleton et al., 2012). The 2005 Millenium Ecosystem Assessment (MEA) attributed this loss to urban development, resource extraction, introduction of invasive plant species and an increase in coastal population (Finlayson et al., 2005).

Restoring and sustainably managing coastal wetlands requires strong efforts to counter their loss and degradation. Gathering public support is critical in protecting wetlands as it can help to ensure social commitment towards sustainable use and management of restored wetlands (Scholte et al., 2016) as well as influence policy intervention. Understanding culture can give a much deeper insight into how people value wetlands (Hirons et al., 2016) and their willingness to support wetland's conservation agenda.

Human culture is embedded within natural systems (including coastal wetlands) and influences how people in a community perceive the world and interact with their environment (de Groot et al., 2002; Pröpper & Haupts, 2014). Conservation of wetlands depends on cultural elements that include human attitudes and activities; and presenting information about wetlands, in a way that reflect people's cultural values, could strengthen conservation (Papayannis, 2011). This could be a reason why integrating the concept of culture in wetland management was mandated by decisions of the Conference of the Parties of the Ramsar Convention through Resolution IX.21 (paragraph 13) made at its 9th meeting, which encourages contracting Parties to "incorporate cultural values in wetland policies and strategies, as well as in wetland management plans, and to communicate the results, thus contributing to the development of comprehensive and integrated approaches" (Ramsar Convention, 2005).

Incorporating culture in wetland policies and strategies requires culture's adequate valuation for it to be well represented. However, culture is difficult to capture and measure mainly because it has no universally agreed definition and people define it depending on their own perspective (Atalay & Solmazer, 2021; Caprar et al., 2015). The concept of ecosystem services (ES) was developed to estimate the value of benefits humans get from the ecosystem (known as ecosystem services) so that more informed policy and management decisions are made (Fisher et al., 2009). ES concept is therefore important in providing a means to measure culture within the context of cultural services.

ES are defined as an ecosystem's functions or processes that directly or indirectly sustain and fulfill human life, i.e. benefits people obtain from an ecosystem (Costanza et al., 2017; Daily, 1997; Millenium Ecosystem Assessment, 2003). According to the Millenium Ecosystem Assessment (2003), ES are categorised into provisioning, regulating, cultural and supporting services. Provisioning services include products humans obtain from the ecosystem (e.g. food and water) while regulating services are benefits that are obtained from regulation of ecosystem process (e.g. climate regulation and pollination) (Millenium Ecosystem Assessment, 2003). The Millenium Ecosystem Assessment (2003, p. 58) further identified cultural services as "nonmaterial benefits people obtain from ecosystems through spiritual enrichment,

cognitive development, reflection, recreation and aesthetic experiences." Examples of cultural services include recreation, ecotourism, cultural heritage, educational value, aesthetic value and spiritual value Supporting services are basic ecosystem processes and functions that contribute indirectly to human wellbeing by maintaining the processes and functions of all the other three categories of ES. Examples of supporting services include soil formation, nutrient cycling, and provision of habitat (Costanza et al., 2017).

Cultural ecosystem services (CES) reflect the cultural dimension of the ecosystem's contribution to human well-being. Generally, CES are difficult to estimate and quantify because they are intangible and nonmaterial (Cheng et al., 2019; Tilliger et al., 2015). Intangible services are psychological in nature while nonmaterial services do not have a physical form hence their valuation is subjective as it depends on one's perception and experience. In addition to that, boundary among different CES categories is unclear and this may lead to double counting problems when assessing CES value (Cheng et al., 2019). For example, benefits from recreational services may be linked to aesthetic, educational or spiritual values of the ecosystem hence valuation of recreational services alone may inadvertently include value of associated CES categories. Because of all these challenges, CES remain poorly understood, their economic evaluation is generally subject to controversy (due to use of quantitative approaches when assessing intangible services) and are often under-valued in research and assessment of ES (Martin et al., 2016; Plieninger et al., 2013; Tilliger et al., 2015). It is therefore not surprising that CES was the least captured ES in the Millenium Ecosystem Assessment as observed by Costanza et al (2017). This study is interested in promoting protection of coastal wetlands by understanding people's cultural attachments to these natural systems and exploring methods that are used to adequately quantify cultural values that may be used in influencing policies for wetland conservation. The concept of CES is used in this study as a tool to explore methods used to value culture in various research studies across the world. This study aims at understanding how culture is measured by investigating and analysing methods used in CES associated with coastal wetlands. The following are the study's objectives:

i. To investigate the role and importance of coastal wetlands and the need to protect them
ii. To explain why an understanding of culture is relevant to the protection of coastal wetlands
iii. To develop an understanding of the concept of culture
iv. To introduce CES that recognises culture as part of placing value on ecosystems
v. To collate the different arrays of methods used in studies measuring or quantifying CES values
vi. To identify which CES categories are represented in research measuring or quantifying CES
vii. To analyse the implications of these findings in relation to the protection of coastal wetlands

The study used systematic literature review approach to collect and consolidate data on CES valuation methods from relevant peer-reviewed research papers.

2. Background and Context

Basic information about coastal wetlands' description, reasons for their loss and people's perception towards them as well as understanding the concepts of ES and cultural service provides a basis for their protection from loss and degradation. This section synthesizes information from relevant studies to give background information about coastal wetlands and contextualizes it within the CES concept.

2.1 Coastal Wetlands

2.1.1 Description

Coastal wetlands are complex social-ecological systems located in areas where freshwater and saltwater mix and are found in form of mangrove forests, salt marshes, seagrass beds, tidal flats, rivers, estuaries, coral reefs and continental shelves (Hopkinson et al., 2019; Navarro & Rodríguez-Santalla, 2023; Newton et al., 2020). These natural systems have seaward and landward margins that link them to the sea and land respectively. The seaward edges of coastal wetlands are mostly habitat for benthic algae and sea grasses while the landward margin experiences occurrence of baren salt flats (in arid climates) and supports swamp communities dominated by fens, trees and shrubs (in humid or tropical climates) (Hopkinson et al., 2019; Maynard & Wilcox, 1997).

In terms of their global distribution, Pendleton et al (2012, p. 2) found that "seagrass beds are found from cold polar waters to the tropics. Mangroves are confined to tropical and sub-tropical areas, while tidal marshes are found in all regions, but most commonly in temperate areas". These ecosystems are characterized by a unique combination of hydrology, soil conditions, and vegetation that enable them to thrive in harsh coastal environment (Navarro & Rodríguez-Santalla, 2023). Generally, coastal wetlands' organic and mineral soils are covered or saturated by tidal freshwater, brackish or saline water and support the growth of emergent and submerged vascular plants that help to slow water movement, promotes settling of particles, and accelerate tidal wetland expansion (Hopkinson et al., 2019; Kennedy et al., 2014).

Natural processes taking place in coastal wetlands may influence the wetland's properties. Hopkins et al (2019) noted that the exchange and mixing of water and materials entering the wetland from rivers and oceans, defines the overall structure and distribution of the wetland's elements. Nutrient-laden freshwater from rivers mixes with ocean water (through tidal movement) and goes into the wetland, making these ecosystems to be among the most productive natural systems on earth (Good et al., 1999). The wetland's water depth, tidal range, and salinity are some of the elements that are determined by sediment deposition and distribution (Hopkinson et al., 2019).

Freshwater and salt water that drain into coastal wetlands come from different sources. For instance, river flooding, groundwater seepage and terrestrial runoff (caused by high rainfall) are some of the sources of freshwater while rising tides in seas and oceans drive salt water to coastal areas including wetlands (Ewel, 2010).

2.1.2 Loss of Coastal Wetlands

There has been a significant loss of wetlands for the past centuries across the world. The loss of both inland and coastal wetlands in the 20th and 21st centuries has happened at a much faster rate (3.7 times) than previously (Davidson, 2014). Specifically, about 8,000km^2 of coastal wetlands are lost every year and it is projected that 30-40% of tidal marshes and seagrasses, and nearly 100% of mangroves could be lost in the next 100 years if current loss rate continues (Pendleton et al., 2012).

The Millenium Ecosystem Assessment (2005) identified human urban development, population growth and resource extraction as some of the main causes of degradation and loss of coastal wetlands. On population growth, the global coastal population has been increasing from about 1.9 billion in 2010 to 2.15 billion in 2020 (Reimann et al., 2023) and this has placed more pressure on coastal resources. Increased demand for waste disposal, transportation, commercial and recreational fisheries; and sites for ports, industries and urban centres have resulted into conversion of coastal wetlands into other land uses

through draining, diking, dredging, excavation, damming, diversion and other alterations (Good et al., 1999).

Increased demand for coastal resources has also resulted into mangroves being cut heavily for charcoal production and diked for fish farming while seagrasses are lost mainly due to nutrient enrichment leading to eutrophication (Hopkinson et al., 2019). Additionally, human activities in coastal zones have significantly reduced coastal water quality as they have contributed to increased salinity, temperature, and acidity in saltmarshes, mangroves and sea grasses (Ostrowski et al., 2021).

Lack of incentives to protect coastal wetlands and ensure their continued ecological sustainability has also contributed to loss of coastal wetlands. From economics point of view, market forces give landowners incentives to convert coastal systems at a profit since there are few mechanisms currently in place that would pay landowners, managers, or governments to protect the carbon stored in coastal ecosystem (Pendleton et al., 2012). Even though international agreements and EU legislation (such as Ramsar Convention and the EU Water Framework Directive and the Habitats Directive) aim to prevent the further degradation of wetlands ecosystems, wetlands are still susceptible to drainage and reclamation more especially if there is a major economic interest (Scholte et al., 2016).

2.1.3 Public perception and value of wetlands

Protection of coastal wetlands should be given a priority considering the critical role these environments play in the coastal systems and socio-economic life of coastal population (Good et al., 1999). However, efforts to protect and restore coastal wetlands are hindered by people's perceptions towards wetlands. Meindl (2000, p. 378) stated that people have "viewed coastal wetlands with disdain because they hinder transportation and farming, serve as a refuge for birds that eat their crops, and provide a haven for annoying mosquitoes". In some developing countries, the public blames coastal wetlands for providing habitat to *Vibrio cholerae* (a bacterium that causes cholera infection) which thrives in brackish environment that is rich in organic matter (Wolanski et al., 2009). Because of this negative perception, coastal wetlands' value in the provision of goods and services to the society are not recognized (Scholte et al., 2016).

2.2 Ecosystem Services Concept

The concept of ecosystem services (ES) was introduced with an aim of enumerating the value of the ecosystem's benefits so that society can make more informed policy and management decisions (Westman, 1977 cited in Fisher, et al., 2009). The ES concept appeared in the late 1970s when it was referred to as 'nature's services' (Costanza et al., 2017). Different authors have come up with different ES definitions to capture the key elements of the concept. Costanza et al (2017) defined ES as ecosystem processes and functions that benefit people, consciously or unconsciously, directly, or indirectly. Daily (1997) defined ES as conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. The Millenium Ecosystem Assessment (2005) simply defined ES as benefits people obtain from ecosystem. Examples of ES include pollination of crops, mitigation of floods and decomposition of waste (Daily, 1997).

Integrating ES in environmental management policies can be instrumental in sustainable management of natural systems. Much as the ES concept is increasingly promoted to evaluate benefits derived from natural resources (Wallace, 2007), ES are often given too little weight in policy decisions because they are not fully captured in commercial markets or adequately quantified in terms comparable with economic

services and manufactured capital (Costanza et al., 1997). Eventually, if natural capital stock that produces ES are not given adequate weight in the decision-making process, current and continued future human welfare may drastically suffer (Costanza et al., 2017).

To ensure that ES are adequately presented in policy formulation and decision-making, efforts have been made to assess and value ES. According to Constanza (2017), the first assessment to value ES was done in 1996 by a team of scholars in environment and conservation who estimated the value of the entire biosphere to be in the range of US$16-54 trillion per year with an average of US$33 trillion per year. The published paper of the assessment received huge amount of positive press coverage as well as controversy and criticism due to its methods and results (Costanza et al., 2017). From that time onwards, ES research has become an important area of research and the number of papers addressing this concept have been rising exponentially (Fisher et al., 2009). In addition to that, the concept of ES has now become the basis for a large and rapidly expanding literature that seeks variously to measure, assess, and value the aspect of societal dependence on nature (Lele et al., 2013).

The second significant ES assessment was the Millenium Ecosystem Assessment (MEA) which was initiated by United Nations in 2000 and finalized in 2005. The assessment aimed at analysing and, as much as possible, quantifying the importance of ecosystems to human well-being to make better decisions regarding the sustainable use and management of ES (Millenium Ecosystem Assessment, 2003). Further to that, the MEA calls for increased and concerted research on measuring, modelling, and mapping ecosystem services, and assessing changes in their delivery with respect to human welfare (Fisher et al., 2009). The MEA emphasized more on the concept of Total Economic Value (TEV) as a widely used framework for looking at the utilitarian value of the ecosystems i.e. human beings derive their satisfaction (directly or indirectly) from the ecosystems. It further disaggregated TEV into two categories: use values and non-use values. Use value refers to the value of ES that are used by humans for consumption or production purposes while non-use values are those that humans ascribe value to, knowing that a resource exists, even if they never use that resource directly (Millenium Ecosystem Assessment, 2003).

To effectively operationalize ES assessment, MEA categorized ES into provisioning, regulating, cultural, and supporting services as shown in Table 1.

2.2.1 Provisioning ecosystem services

These are products that are extracted and consumed from ecosystem, and they often have a market value (Balvanera et al., 2017). Goods or products that humans benefit from coastal wetlands include fibre, genetic resources, fish, wildlife, waterfowls, rice (through farming) and wood (Brazner et al., 2000; Maynard & Wilcox, 1997; Millenium Ecosystem Assessment, 2003). Fish is one of the major sources of protein to humans and it is estimated that two-thirds of all the fish consumed worldwide are dependent on coastal wetlands (Convention on Wetlands, 2021).

Table 1: Categories of ES and their examples

Provisioning Services *Products obtained from ecosystems.* • Food • Fresh water • Fuelwood • Fiber • Biochemicals • Genetic resources	**Regulating Services** *Benefits obtained from regulation of ecosystem processes.* • Climate regulation • Disease regulation • Water regulation • Water purification • Pollination	**Cultural Services** *Nonmaterial benefits obtained from ecosystems.* • Spiritual and religious • Recreational and ecotourism • Aesthetic • Inspirational • Educational • Sense of place • Cultural heritage
Supporting Services *Services necessary to produce all other ecosystem services* • Soil formation • Nutrient cycling • Primary production (production of biomass)		

Source: Millenium Ecosystem Assessment (2003)

2.2.2 Regulating ecosystem services

These are benefits obtained from the regulation of ecosystem processes and are related to ecosystem's capacity to regulate essential ecological processes and life support systems through bio-geochemical cycles and other biospheric processes (de Groot et al., 2002). These services have direct and indirect benefits to humans and examples include air quality maintenance, storm protection, climate regulation, erosion control and water purification (Costanza et al., 2017; de Groot et al., 2002; Millenium Ecosystem Assessment, 2003). In water purification, coastal wetlands provide natural water treatment mechanisms that filter pollutants before they enter coastal waters that are used for both domestic and commercial purposes (Gu et al., 2007).

Coastal wetlands protect coastal communities from storms with high wind speed, extreme waves and tsunamis, which can cause flooding, erosion, loss of capital infrastructure and human lives (Kron 2009 as cited by Brown et al., 2013; Wolanski et al., 2009). The protective function is enhanced by wetlands' ability to decrease surges and waves as well as reduce flood damages by absorbing flood waters caused by rain (Brown et al., 2013; Costanza et al., 2021). In addition, their capacity to store flood waters is protective as they are slowly released to downstream areas after the flood peak (Maynard & Wilcox, 1997).

Regulating climate is an important ecosystem service considering the devastating effects climate change has caused globally. Coastal wetlands are among the most effective natural carbon sinks on the planet and carbon sequestration is one of their most important ecosystem services (Navarro & Rodríguez-Santalla, 2023). Carbon sequestration occurs as atmospheric carbon dioxide is captured and converted to organic carbon by plants through photosynthesis and stored as blue carbon in above-ground vegetative

biomass and ultimately buried in the soil, thereby helping to mitigate the effects of climate change (Lovelock & Duarte, 2019; Navarro & Rodríguez-Santalla, 2023; Sheehan et al., 2019). Globally, coastal wetlands store significant amounts of atmospheric carbon which is estimated on average to be 512 tonnes carbon per hectare for seagrasses, 917 tonnes carbon per hectare for salt marshes and 1,028 tonnes carbon per hectare for mangroves (Pendleton et al., 2012). The blue carbon can remain stable for hundreds or thousand years but once disturbed and drained, the long-sequestered soil carbon is re-oxidized back into the atmosphere, leading to significant carbon emission which contributes to climate change (Convention on Wetlands, 2021; Pendleton et al., 2012). The potential impacts that come from releasing stored coastal blue carbon to the atmosphere are felt globally (especially in low-income countries) through effects associated with climate change such as increased droughts, sea level rises and high frequency of extreme weather events (Pendleton et al., 2012).

From a different perspective, it is suggested that coastal wetlands are contributing to climate change through emission of methane which is produced by large volumes of soil organic matter as well as anaerobic conditions that occur in the coastal wetland (Navarro & Rodríguez-Santalla, 2023). However, most of coastal wetlands are net carbon sinks and not sources of gases that contribute to climate change (Mitsch et al., 2013). If not disturbed, coastal wetlands are a powerful carbon sink and their rate of sequestration in 55 times faster than tropical rainforests (McLeod et al., 2011).

2.2.3 Cultural ecosystem services (CES)

These are contributions the ecosystems make to human well-being in terms of the identities they help frame, the experiences they help enable and the capabilities they equip (Fish, Church, Willis, et al., 2016). Humans experience these benefits through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences (Finlayson et al., 2005). Examples of cultural services are non-consumptive recreational services such as bird watching, nature study, photography, tourism and cottaging (Maynard & Wilcox, 1997). According to Hirons et al (2016), CES intertwine and overlap with other ES categories, but they are distinct from other categories because they are non-substitutable in the way other ES may be (i.e. they are unlikely to be replaced by technical or other means once they are degraded). In addition to that, CES are intuitive and largely subjective in nature since people perceive them differently depending on their background, experiences, cultural heritage, age and gender (Hirons et al., 2016). CES will be discussed in more details below.

2.2.4 Supporting ecosystem services

These are ES that are necessary to produce all fundamental ES described above. The ecosystem functions contribute indirectly to human wellbeing by maintaining the processes and functions necessary for provisioning, regulating, and cultural services (Costanza et al., 2017). According to the Millenium Ecosystem Assessment (2003), supporting services differ from other services in that their impacts on people are either indirect or occur over a very long period.

A good example of ecosystem's supporting services is the provision of habitat to flora and fauna which contributes to humans' access to provisioning services (e.g. food) or cultural services (e.g. bird watching). Coastal wetlands are regarded as reservoirs of biodiversity because they provide habitat to plants, fish species, wildlife, macroinvertebrate communities, and migratory and resident birds (Brazner et al., 2000; Wolanski et al., 2009). Many species of fish, amphibians, mammals and reptiles use these wetlands on a permanent or temporary basis for feeding, egg-laying, nursery and shelter while birds use them for

nesting and stopover areas in the case of migratory birds (Maynard & Wilcox, 1997). In some cases, coastal wetlands have been instrumental in conservation of endangered species by providing breeding and feeding places to such species. An example is small number of saltmarshes in Victoria, Australia, that have become a habitat for critically endangered, orange-bellied parrot (*Neophema chrysogaster)* (Saintilan et al., 2019).

2.2.5 Criticism of MEA's ES classification

The classification by Millenium Ecosystem Assessment faced criticism from Wallace (2007) who argued that the classification system mixed processes (or means) for achieving services and the services themselves and therefore the classification cannot be used for effective decision-making. For example, pollination, water regulation, photosynthesis and soil formation are ecosystem processes (means) to achieve ecosystem services (an end) such as food production and portable water. In broader terms, regulating and supporting services are generally means to achieve provisioning and cultural services. In support of this argument, Lele et al (2013) observed that ES researchers are treating ecosystem processes and ecosystem functions synonymously and this is problematic because it leads to either double counting or counting of and comparison between variables at different levels. For example, nutrient cycling is not an ecosystem service but a process that contributes to a service such as timber production. Valuing nutrient cycling in addition to timber would then lead to double counting (Lele et al., 2013). This problem has been exacerbated by lack of clarity in defining key terms. Wallace (2007) argued that ambiguous definition of key terms such as ecosystem processes, functions and services has caused problems in ES classification that can be used to effectively make decision on biodiversity.

2.3 CES in broader perspective

As pointed out earlier, the concept of CES highlights the importance of natural systems in supporting a range of life-enriching and life-affirming benefits to humans (Fish & Church, 2014). The concept may be used as a vehicle for communicating the importance of protecting ecosystems because CES are directly experienced and intuitive (Hirons et al., 2016).

2.3.1 CES categories

On categorisation of CES, Hirons et al (2016) observed that determining what constitute CES is not easy due to debatable definitions of culture and because values are important across all services. However, the purpose of distinguishing categories of cultural services is to highlight that there are nonmaterial and nonconsumptive ecosystem services that are important to people's physical and mental states (Hirons et al., 2016). Nonconsumptive services are those that are used and enjoyed by humans without reducing their supply (e.g. bird watching)

CES were categorised differently by different initiatives notably: Common International Classification of Ecosystem Services (CICES), the Millenium Ecosystem Assessment (MEA) and The Economics of Ecosystems and Biodiversity (TEEB). The MEA, described in the previous section, was the first large scale ecosystem assessment, and it provided an ecosystem services framework that has been adopted and further refined by TEEB and CICES (European Commission, 2013). The MEA categorised CES into the following: cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation and tourism. Each of these categories was defined as shown in table 1.

Table 2: Categories of CES and their description as quoted from the 2005 Millenium Ecosystem Assessment

CES Category	Description
Cultural diversity	The diversity of ecosystems is one factor influencing the diversity of cultures
Spiritual and religious values	Many religions attach spiritual and religious values to ecosystems or their components.
Knowledge systems	Ecosystems influence the types of knowledge systems (both traditional and formal) developed by different cultures
Educational values .	Ecosystems and their components and processes provide the basis for both formal and informal education in many societies
Inspiration .	Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising
Aesthetic values	Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, "scenic drives," and the selection of housing locations.
Social relations	Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies.
Sense of place .	Many people value the "sense of place" that is associated with recognized features of their environment, including aspects of the ecosystem
Cultural heritage values	Many societies place high value on the maintenance of either historically important landscapes ("cultural landscapes") or culturally significant species.
Recreation and ecotourism .	People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area

Source: Cheng et al (2019)

TEEB updated the MEA classification by categorizing CES into spiritual experience, aesthetic information, inspiration for culture, art and design; recreation and tourism; and information for cognitive development (European Commission, 2013). CICES is more hierarchical in structure than MEA. Its hierarchical structure (arranged as theme, class and group in that order) was proposed as a way of handling some of the challenges that arise in relation to the different spatial and thematic scales used in different applications (Haines-Young & Potschin, 2012; Potschin & Haines-Young, 2011). CICES grouped CES into two first-order divisions: (a) those related to physical and intellectual interaction with ecosystems (b) those interaction that are better defined as spiritual or symbolic (Hirons et al., 2016). Table 3 shows how the CES are categorized based on CICES hierarchy and how MEA and TEEB typologies are linked to CICES typology.

2.3.2 CES Conceptual Framework

CES are theoretically conceptualized in a framework based on the assumption that understanding CES reflects and creates a wider set of cultural values whose key elements (i.e. cultural norms and expectations) influence and are influenced by ecosystem's services, benefits and biophysical context (Fish, Church, & Winter, 2016). Figure 1 illustrates CES conceptual framework comprising of four key dimensions namely: cultural values, environmental spaces, cultural practices, and cultural benefits. According to Fish et al (2016), the framework is based on the argument that environmental spaces (i.e. places, landscapes and seascapes in which people interact with the natural environment) and cultural practices (i.e. expressive, symbolic and interactive interactions between people and the natural environment) jointly strengthen CES through which cultural benefits to well-being arise. The biophysical domain of the ecosystem is shaped by environmental spaces and cultural practices while at the same time it (biophysical domain) provides the physical and non-human components of the environmental spaces and opportunities for cultural practices ((Fish, Church, Willis, et al., 2016; Fish, Church, & Winter, 2016). The conceptual framework also shows that cultural ecosystem benefits (which are distinguished in terms of identities, experiences and capabilities) shape the environmental spaces and cultural practices (Fish, Church, Willis, et al., 2016).

Because cultural services are tightly bound to human values and practices as highlighted in the framework, perception of cultural services are more likely to differ among individuals and communities (Millenium Ecosystem Assessment, 2003). For instance, (Martin et al., 2016) found that prioritization of wetlands' cultural services differs among nations with different economic status. In developed countries, cultural services provided by natural wetlands are highly valued by the societies for their therapeutic and recreational benefits while developing countries value cultural services more for their cultural identity and survival (Martin et al., 2016).

Table 3 Categorisation and examples of CES based on CICES structure and showing the links between the CICES and MEA and the CICES and TEEB initiatives

Division	Group	Class	Examples
Physical and intellectual interaction	Physical and experiential interactions[1]	Experiential use of plants, animals, and land-/seascapes in different environmental settings	Whale or bird watching, snorkelling, diving
		Physical use of land-seascapes in different environmental settings	Walking, hiking, kayaking, boating, recreational fishing, using urban green spaces
	Intellectual and representative interactions[2]	Scientific	Subject matter for scientific research e.g., pollen record, genetic patterns
		Educational	Subject matter of educational value, e.g., for school trips, books
		Heritage, cultural	Historic records of a place; cultural heritage preserved in water bodies or soils e.g., pottery remains, relics
		Aesthetic	Artistic representations of nature
		Entertainment	Ex situ viewing of the natural world through different media, e.g., wildlife television programs
Spiritual and symbolic	Spiritual and/or emblematic	Symbolic	Emblematic plants and animals; national symbols, e.g. English rose, American eagle, South African springbok
		Sacred and/or religion	Holy or spiritual places important to spiritual or ritual identity, e.g., River Ganges in India, sacred forest groves, sacred plants or animals
	Other cultural outputs	Existence	Enjoyment and philosophical perspective provided by the knowledge of, and reflection on, the existence of wild species, wilderness, or land-/seascapes, e.g., presence of the Amazon rainforest and its wildlife for dwellers of South America's capital cities
		Bequest	Willingness to preserve plants, animals, ecosystems, and land-/seascapes for the experience and use of future generations, e.g., long-term conservation

Source: Hirons et al (2016)

[1] MA: recreation and tourism; TEEB: recreation and tourism

[2] MA: knowledge systems, educational values, cultural diversity, and aesthetic values; TEEB: information and cognitive development; inspiration for culture, art and design, aesthetic

According to Fish et al (2016), CES framework demonstrates the element of culture that is integrated in the ecosystem. In principle, CES presents a way in which the cultural dimension of ecosystem contributions to human well-being can be utilized in decision making through standardised comparison with all other ES (Fish, Church, & Winter, 2016). Therefore, describing what culture is and how it is quantified is very important in understanding the CES concept.

Figure removed due to copyright restriction.

Figure 1: CES Conceptual framework
Source: Fish, Church & Winter (2016)

2.3.3 What is culture and how is it measured?

Culture has no unified definition but numerous definitions that define it from various perspectives (Atalay & Solmazer, 2021). This was supported by Xing and Jin (2023) who stated that culture is defined differently depending on the field of study. In addition to that, culture is difficult to define because it is a fuzzy concept which means it is a term without fixed boundaries and changes its meaning according to situations (Causadias, 2020).

The difficulty in defining culture makes it difficult to measure (Caprar et al., 2015). In most cases, measuring culture uses instruments or tools that quantify attitudes, practices and values (Taras et al., 2009). Attitudes are relatively enduring organization of beliefs around an object or situation predisposing one to respond in some preferential manner and are measured by simply asking respondents to report their attitudes to the presented object (Albarracin & Shavitt, 2018; Hofstede, 1998). Cultural practices are participatory dynamics, community engagements, and culture in action, including teaching, learning and participating in everyday activities, traditions, and rituals (Causadias, 2020). They are a visible part of culture, and they reflect symbols, heroes and rituals that are specific to one culture (Hofstede, 1998). Cultural values refer to shared beliefs and goals among members of society regarding patterns of behaviour and ways of life (Xing & Jin, 2023). They are collective principles and life goals, and the associated norms and expectations that influence significance and meaning of ecosystem to people (Fish, Church, & Winter, 2016).

In measuring culture, cultural values are key variable because they highlight how much people are attached to the natural environment. In a community setting, cultural values represent an important facet of lives, livelihood and cultural identity of the local community and primary stakeholders hence determination of these values is important in generating community investment in wetland conservation (Himes-Cornell et al., 2018). Similarly, decisions on land use and land use conversion could be based on assessment of the entire wetland to forecast the effects of potential developments on local communities who have a special connection to the wetland (Ewel, 2010).

According to Hirons et al (2016), cultural values that are individually or collectively held shape the valuation methods that are chosen to obtain and express them. The choice of valuation method is therefore critical in revealing or hiding values (Hirons et al., 2016). Taras et al (2009) found that self-report questionnaires are perceived to be the best tool for the task of quantifying culture. Questionnaires use rating and ranking (rank ordering) as major types of items in measuring culture. Ranking allows respondents to express sharp preferences between every pair of values while rating does not force respondents to discriminate among equally important values (Taras et al., 2009).

2.3.4 Measuring CES

Because culture is an integral part of CES, understanding different methods of measuring CES gives a clear picture of how cultural values are quantified in the assessment of ES. However, according to Martin et al (2016), measuring CES is challenging because of their intangible and subjective attributes that make them difficult to value in monetary terms. As a result, CES are often under-represented in ecosystem services research and assessment (Martin et al., 2016). This was also reflected in the Millenium Ecosystem Assessment where CES was the least developed ES category (Costanza et al., 2017).

Nonetheless, CES have been measured, assessed or evaluated by different researchers using different methods that are either monetary or non-monetary. While monetary approaches are used to capture the economic value of CES, non-monetary approaches allow greater in-depth assessments of the motivation underlying people's value for ecosystem (Christie et al., 2012). Both monetary and non-monetary methods can further be classified into revealed preference and stated preference methods. According to Cheng et al., (2019), monetary revealed preference methods are those that observe the actual markets related to the CES to assess the CES value while monetary stated preference methods are those that create a hypothetical market and ask respondents to directly state their willingness to pay, receive,

accept, or give up some services. On the other hand, non-monetary revealed preference methods are those that observe behaviour or analyse documents (e.g. written text and advertisements) to directly determine human's CES preference while non-monetary stated preference methods are those that directly ask about one's values to assess CES (Cheng et al., 2019). Some examples of these valuation methods are explained in Table 4.

Table 4: Examples of Monetary and Non-monetary methods for valuation of CES

Monetary Methods		
Classification	*Methods*	*Description of method from the perspective of CES*
Revealed preference	Market price	An estimated economic value of CES is based on the market price of a product, thus according to Cheng et al (2019). For instance, CES in recreation and ecotourism can be calculated based on both the entrance fees paid to the parks and on the revenue generated in the local ecotourism sector (Cheng et al., 2019).
	Travel cost	Utilises a microeconomic model explaining an individual's behaviour that leads to visiting a recreational site; it incorporates the purchase and use of cultural services by visitors to the site (Martín-López et al., 2009). In other words, travel cost values recreation and ecotourism in ecosystems by using the travel cost to destinations where recreational activities, such as wildlife viewing, hunting, and fishing, are available (Cheng et al., 2019).
	Hedonic pricing	Hedonic Pricing Method is a commonly used method that quantifies the monetary value of nonmarket benefits and is based on the relationship between a house price and its characteristics (Cheng et al., 2019; Dahal et al., 2019). For example, CES can be estimated from a rise in prices of house rentals caused by an improvement of water quality due to river restoration (Cheng et al., 2019)
	Benefits/Value transfer	Benefit or value transfer uses economic information captured at one place and time to make inferences about the economic value of CES at another place and time (Richardson et al., 2015; Wilson & Hoehn, 2006). For instance, the cost per trip per person in an existing study is adjusted and transferred to a new study for the calculation of recreation and ecotourism services (Cheng et al., 2019).
Stated preference	Willingness to Pay (WTP) (also known as contingent valuation)	Participants are asked to express the value of an ecosystem service through the amount of money that they would be willing to pay to encourage (or prevent) a change in the provision of a given ecosystem service (Hirons et al., 2016)
Non-Monetary Methods		
Revealed preference	Document analysis	Looks at texts, images, or other forms of materials to obtain information about human preferences on CES based on aesthetic value (Cheng et al., 2019)
	Social media-based	Values CES based on the social media data from various resources such as photograph-sharing websites that include Flickr and Instagram (Cheng et al., 2019). Photographs of landscape may be inspired by a feeling of sense of place and provide insights into the perceived relative importances of different visual elements (Ghermandi et al., 2020; Richards & Friess, 2015).
Stated preference	Interview	Directly gains a deeper understanding about how and why people value CES through face-to-face interaction or other techniques (Cheng et al., 2019)

	Questionnaire survey	Consists of a series of questions for the purpose of gathering information about CES from respondents (Cheng et al., 2019)
	Focus group discussion	Provides an opportunity to respondents to obtain more information and allows time for reflection or group discussion (Cheng et al., 2019)
	Q Method	Involves deriving a set of opinion statements from various sources such as scholarly articles, blogs, face to face interviews, newspaper articles and social media (Gall & Rodwell, 2016; Pike et al., 2015). The statements are examined thoroughly to isolate the most important statements that make a final list known as Q set. Face-to-face interviews are conducted with well-informed key stakeholders to sort statements into a nine-point scale (known as Q sort grid) which ranges from +4 (most like) to -4 (least like) (or from +5 to -5 in some cases). Additional questions are asked to interviewees to shed more light on reasons for their sorting.
	Mapping	Uses Geographic Information Systems (GIS) or other mapping techniques to involve community members make visible the association between land and local communities (IFAD, 2009)
	Problem Centred Interviews (PCI)	Deploys a discursive dialogue procedure in which interviewees are experts in the subject under discussion (Schenk et al., 2007). A problem is represented to respondents subjectively and then stimulated narratives are enriched by dialogue, employing imaginative and semi-structured prompts (Witzel, 2000).

3 Method: Systematic Literature Review

This study used a systematic literature review to evaluate and synthesize studies that attempted to measure CES in coastal wetlands. It is different from the traditional literature review because the actual review process is based on a clearly formulated question, identifies relevant studies, appraises their quality and summarizes the evidence by use of explicit methodology (Khan et al., 2003). This systematic review was done in response to a rise in ES valuation research studies following a release of Millenium Ecosystem Assessment report in 2005. The approach was useful in consolidating knowledge in the valuation of CES in coastal wetlands and provided a general overview of methods used for measuring CES.

Five similar studies conducted between 2016 and 2024 used a literature review to evaluate publications on CES valuation. However, the present study differs from these previous studies in several aspects. First, this study focuses only on coastal wetlands. Second, it places emphasis on how culture has been measured by considering in detail the methods used and assessing their fitness to capture the nuance of this concept. Finally, this study has the broadest data range to all the previous studies as it covers studies conducted in the last twenty years (approximately). The five previous reviews are summarised in Table 2.

Table 5: How present study is different from other studies on CES valuation

Full citation of similar studies	Number of studies reviewed	Difference with present study
Martin, C. L., Momtaz, S., Gaston, T., & Moltschaniwskyj, N. A. (2016). A systematic quantitative review of coastal and marine cultural ecosystem services: Current status and future research [Article]. *Marine Policy*, *74*, 25-32. https://doi.org/10.1016/j.marpol.2016.09.004	24	• Covers articles published from 2007 to 2014 • Reviews studies for both coastal and marine ecosystems • Focuses on non-monetary valuation methods
Himes-Cornell, A., Grose, S. O., & Pendleton, L. (2018). Mangrove ecosystem service values and methodological approaches to valuation: Where do we stand? [Article]. *Frontiers in Marine Science*, *5* (OCT), Article 376. https://doi.org/10.3389/fmars.2018.00376	70	• Covers articles published from 2007 to 2016 • Focuses only on mangroves which is but one component of coastal wetlands • Assesses valuation methods for all ES categories including CES
Cheng, X., Van Damme, S., Li, L., & Uyttenhove, P. (2019). Evaluation of cultural ecosystem services: A review of methods. *Ecosystem Services*, *37*, 100925. https://doi.org/https://doi.org/10.1016/j.ecoser.2019.100925	293	• Covers articles published from 2005 to 2016 • No specification on type of ecosystem
Moore, A. C., Hierro, L., Mir, N., & Stewart, T. (2022). Mangrove cultural services and values: Current status and knowledge gaps [Review]. *People and Nature*, *4*(5), 1083-1097. https://doi.org/10.1002/pan3.10375	58	• Covers articles published from 2002 to 2021 • Focuses on mangroves which is a component of coastal wetlands • Restricted geographical coverage to 25 countries • Focuses on non-monetary valuation methods
Quevedo, J. M. D., & Kohsaka, R. (2024). A systematic review of cultural ecosystem services of blue carbon ecosystems: Trends, gaps, and challenges in Asia and beyond [Article]. *Marine Policy*, *159*, Article 105898. https://doi.org/10.1016/j.marpol.2023.105898	28	• Covers articles published from 2009 to 2021 • No in-depth analysis of valuation methods • CES categories are not assessed with respect to their valuation methods

The systematic literature review was carried out using the method described by Pickering and Byrne (2014) which consists of fifteen stages as shown in figure 3. The approach provides a simplified structure and process for conducting literature review and helps in assessing the literature at the initial stage of the review (Pickering & Byrne, 2014).

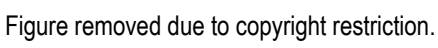

Figure 2: Stages in systematic literature review
Source: Pickering & Byrne, 2014

Of the fifteen steps of the method, the first ten steps are carried out in the process of collecting and analysing data while the last five stages are done during structuring and writing of the paper. Details of each step are outlined below:

3.1 Phase 1: The Process

Step 1 Defining the topic

From a broad field of ecology, which focuses on human-nature interaction, ES as specific topic was identified and defined. ES was narrowed further to CES which became the study's specific topic. Careful reflection on the topic was done to ensure that it is original and appropriate. Specific terms associated with the topic (such as cultural values, marine, saltmarsh, mangroves and value) were identified to facilitate the search process.

Step 2: Formulating the research question

Research questions originated from the identified topic and were formulated with a view of addressing them in the systematic literature review. These questions were (i) what does culture and values mean in relation to management of coastal wetlands? (ii) what significance do CES have in the ecosystem assessment framework? (iii) how is CES classified based on MEA, CICES and TEEB typologies (iv) what methods are used to measure CES for coastal wetlands? (v) what are strength and limitations of these methods? These questions were crucial in understanding and sourcing relevant information for the study.

Step 3: Identifying keywords

Keywords associated with the topic (such as coastal wetlands, cultural values, marine, saltmarsh, mangroves and cultural ecosystem services) were identified to facilitate the search process. Keywords from frequently cited papers were considered as a starting point for identification of study keywords. Search strings were then formulated by combining keywords (or their synonyms) with Boolean operators (specifically OR and AND). The following were search strings that were used to search for articles in a database:

i. "Coast*" OR "wetland*" OR "marine" AND "cultural ecosystem services" AND "valu*"
ii. "Coast*" OR "marine" OR "wetland*" AND "cultural values*"
iii. "Coast*" OR "marine" OR "wetland*" AND "cultural ecosystem services"

Step 4 Identifying and searching databases

Scopus was identified as a scholarly database for the study. This database was selected because of its functionality and scope as it has a 20% higher coverage than other databases (e.g. Web of Science), representing a greater range of peer reviewed journals (Mongeon & Paul-Hus, 2016). Google Scholar was used for backward search using reference lists of previous studies.

The search was restricted to English articles that were published from 2005 up to date. This period of publication was chosen because the concepts of ES gained more attention after the publication of Millenium Ecosystem Assessment synthesis reports in 2005 which resulted into an almost exponential rise of literature on the ES framework (Hirons et al., 2016). The results of the search are reproducible and provide accurate information of the relevant past studies.

Step 5: Reading and assessing publications

This process involved carefully reading through each of the publications collected in Step 4 to determine its relevance and inclusion. An important criterion that was used in the selection was the article's clear description of method used to measure, assess or quantify CES of any of the components of coastal wetlands (i.e. mangroves, seagrasses and saltmarshes). The other criterion was to ensure that the publication was peer-reviewed and was a primary source of information. This gave a proof of its originality and authenticity. Relevant book chapters and reports were also included.

Step 6: Structuring a database of found items

A personal database was developed in Microsoft Excel sheet with columns showing the author, title, year of publication, study location and method used to measure CES. This was in addition to a more detailed library that was created in EndNote by exporting search results from Scopus. Articles' abstracts in Endnote library were key in preliminary filtering of relevant publications.

Step 7: Entering first 10% of papers

In the Microsoft Excel database that was created, 10% of the searched results (3 articles) were entered and aligned to the identified categories (i.e. author, title, year of publication, study location and full citation). This helped to check how well the categories would work when populating the database with the rest of the papers.

Step 8: Testing and revising categories

This process mitigated the need to modify the whole database at a later stage of review if issues arise (such as more details for an existing category). Through testing and revising of categories, subcategories that were not necessary were removed. In some cases, categories that had lots of information were split into subcategories to provide more details. In general, this step assisted in determining whether to add important subcategories or remove irrelevant ones. Most importantly, the process of testing and revising categories was continuously done from the stage of entering 10% of papers (stage 7) through to stage of producing and reviewing summary tables (stage 10 explained below) to ensure no further modification of database in the remaining stages of review.

Step 9: Entering bulk of papers

This step involved entering the final list of searched articles into the Microsoft Excel database in line with the identified categories (Appendix 1).

In summary, the whole search process generated a total of 781 articles which were screened and filtered to come up with a final list of 31 articles as shown in table 3

Table 6: selection process of articles for systematic literature review

Task	Number of articles
Articles searched in Scopus	781
Removal of duplicates	-201
Title, keywords and abstract screening	-549
Final selection of articles	31

Step 10: Producing and reviewing summary tables

The Microsoft Excel database was used to summarize the information in tabular form. Summary tables contained information on papers published by year, global distribution of the retrieved articles, and a list of methods used to value CES. This helped to identify errors in the data entry process that required the database to be updated, and summary tables regenerated (stage 8).

3.2 Phase 2: Structuring and writing the paper

Step 11: Drafting methods

The method section was drafted by outlining key points that justified the selection of the research topic. In addition to that, the following were drafted: method used in the study, keywords searched, database used, criteria used for identification of relevant articles and categories in the database.

Step 12: Evaluating key results and conclusions

This step involved careful assessment of summary tables of results to determine which results were the most important and why. Findings of this task would form the basis for the conclusion of the paper. Most importantly results from this step were check for their relevance to the overall topic, aim and objectives of the study.

Step 13: Drafting results and discussion

Results that were found and prioritized in step 12 were drafted followed by drafting of discussion of results. This formed a basis from which conclusion would be made

Step 14: Drafting introduction, abstract and references

In addition to drafting introduction and abstract, conclusion was also drafted at this step. List of references were drafted with the help of EndNote.

Step 15: Revising paper until ready for submission

This involved re-reading and revising the paper to check if it is aligned to criteria of academic paper.

4 Results

The following chapter presents results of the systematic literature review; outlining trend of CES research, global distribution of the articles, CES categories measured and their valuation methods.

4.1 General Pattern of Reviewed Articles

The research studies on measuring CES in coastal wetlands reviewed here started a decade after publication of Millenium Ecosystem Assessment report in 2005. The reason for this lag could be that CES are difficult to measure and studies that took place immediately after MEA report focused on other categories of ES. Additionally, CES that were evaluated during this period were possibly targeting other economically productive natural ecosystems (such as marine ecosystems) and not coastal wetlands which were previously perceived as wastelands by the public (Meindl, 2000).

Between 2015 to 2024, a total of 31 articles have been published on methods to measure coastal wetlands' CES. These articles have been published at an average rate of 3 papers per year with the highest number of 5 achieved in 2020 and lowest number of 1 in 2016 (Figure 3).

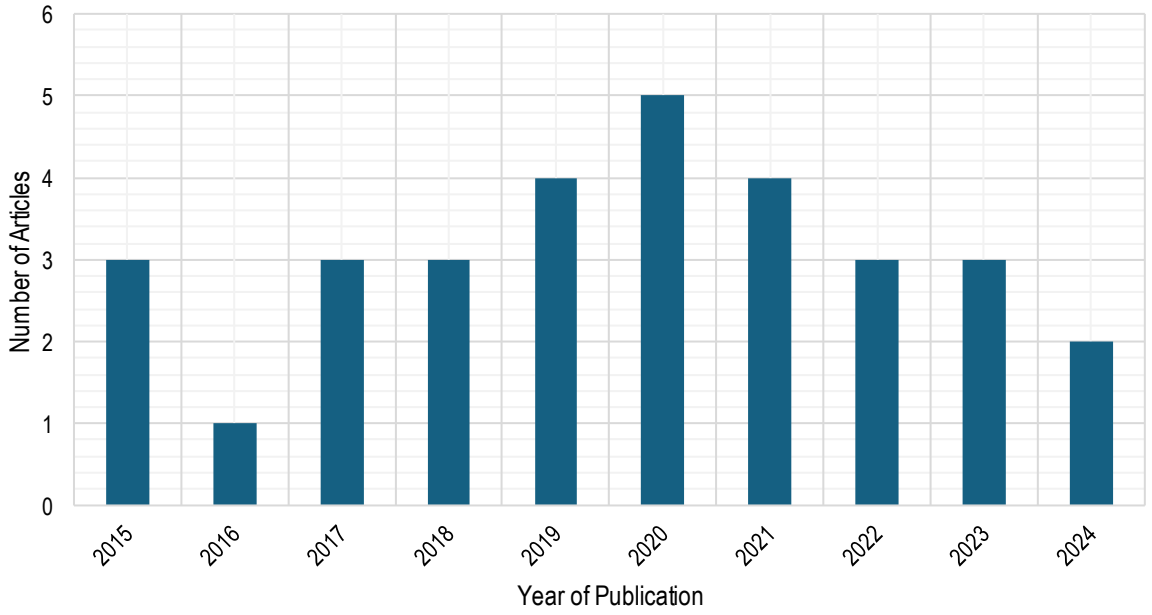

Figure 3: Number of articles published per year

4.2 Geographical Distribution

Out of 31 studies under review, 10 took place in Europe, representing the highest percentage of 32% followed by Asia with 5 articles representing 16%. African and Oceanian countries contributed 4 studies each representing 13% for each region. North America and South America had 3 studies each representing 10% for each region. Only 2 studies (6%) discussed comparative research on several countries across the world (categorized as global) (Figure 4). In terms of the countries' economic status, it was observed that more reviewed studies took place in developed countries than developing nations. This correlates well with (Martin et al., 2016) who suggested that developing countries' economic status leads them to prioritise provisioning services (food and clean water) more than cultural services and may not have funds to pursue CES research. On the contrary, developed nations place greater value on CES and have greater access to funds for CES research (Martin et al., 2016).

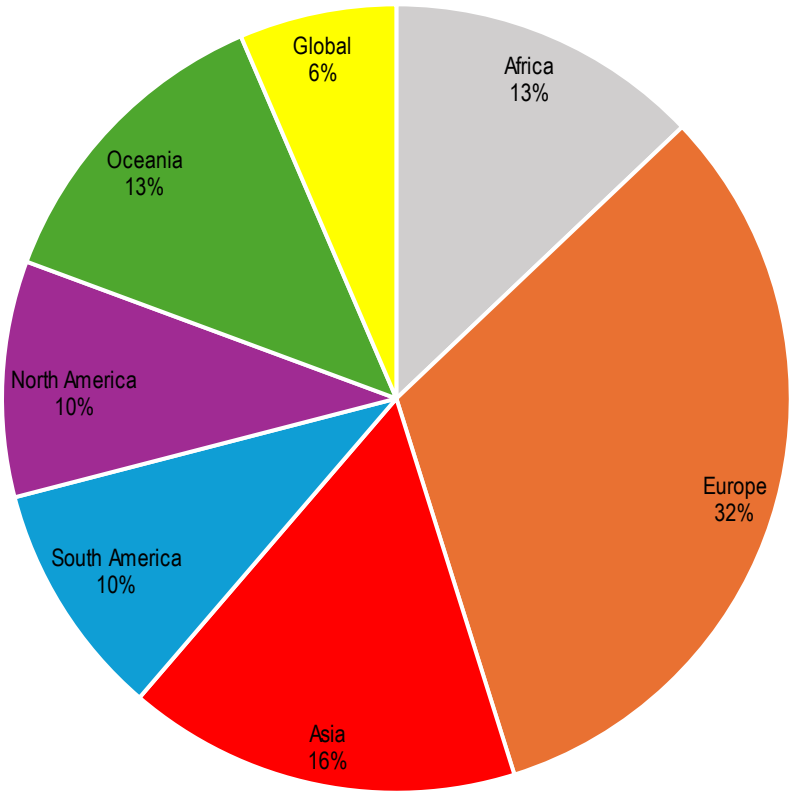

Figure 4: Geographical distribution of articles

4.3 CES Categories

The study adopted the MEA Framework categorization of CES considering that most studies used this framework's categorization, and it is a basis from which other frameworks (i.e. TEEB and CICES) were formulated. Valuation of CES categories was highly uneven as shown in Figure 5. The most measured category was recreation and tourism, followed by aesthetic values, educational values, sense of place and spiritual and religious values, in that order. Inspiration, knowledge systems and cultural diversity were

the least measured CES categories. It is important to note that most studies measured or quantified more than one CES category and pairing recreation and tourism service together with aesthetic value was the most common combination. Only four studies valued a single category which were recreation and ecotourism (in three studies) and aesthetic value (in one study).

In some articles, CES was evaluated alongside other ES classes such as provisioning and regulating services. Consequently, there was little information about CES as compared to other articles where CES was a primary topic of focus.

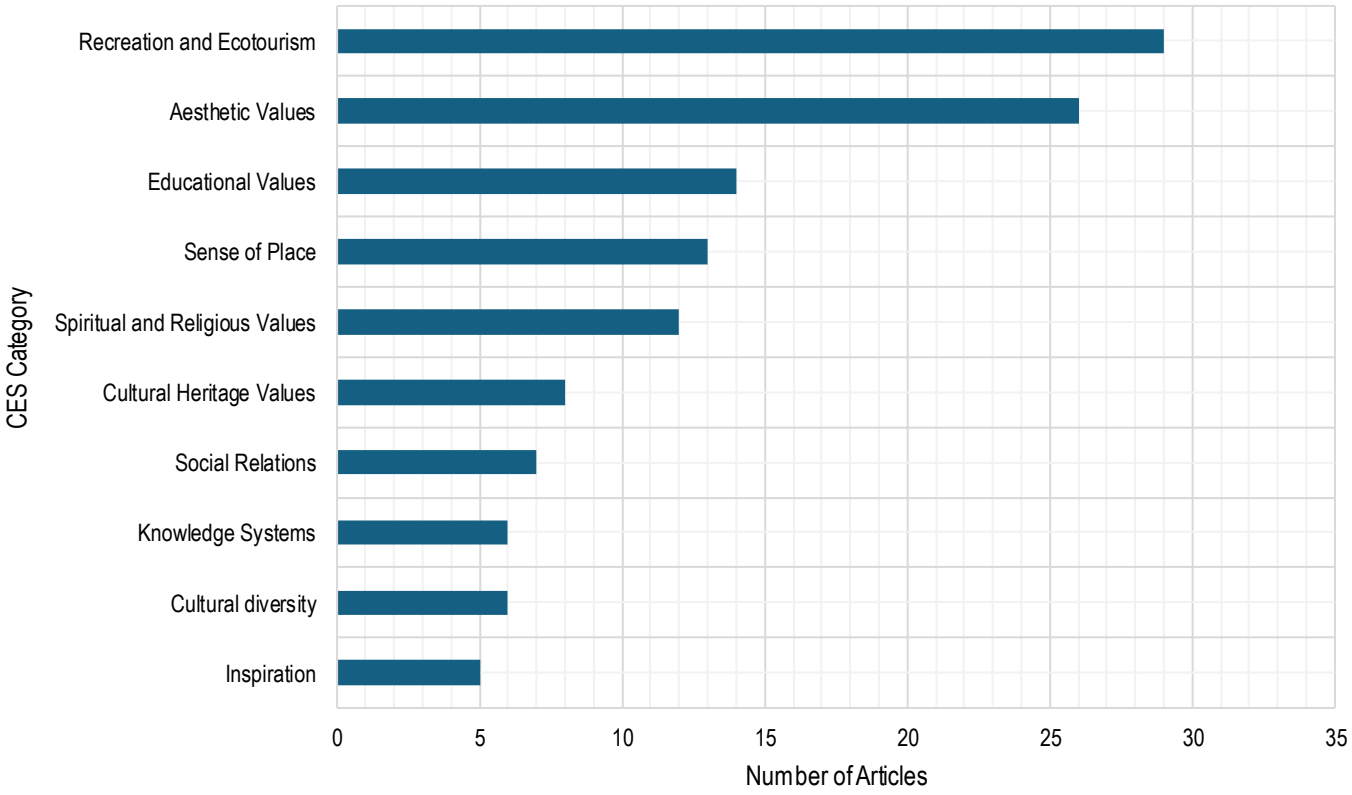

Figure 5: Number of articles valuing CES by category

4.4 CES Valuation Methods

Valuation methods that were used in all the reviewed articles were grouped into monetary, non-monetary and mixed methods (combination of both monetary and non-monetary methods). As shown in Figure 6,

74% of articles (n=23) used non-monetary methods while monetary methods were used in 13% of the articles (n=4). Four articles (13%) combined both monetary and non-monetary methods.

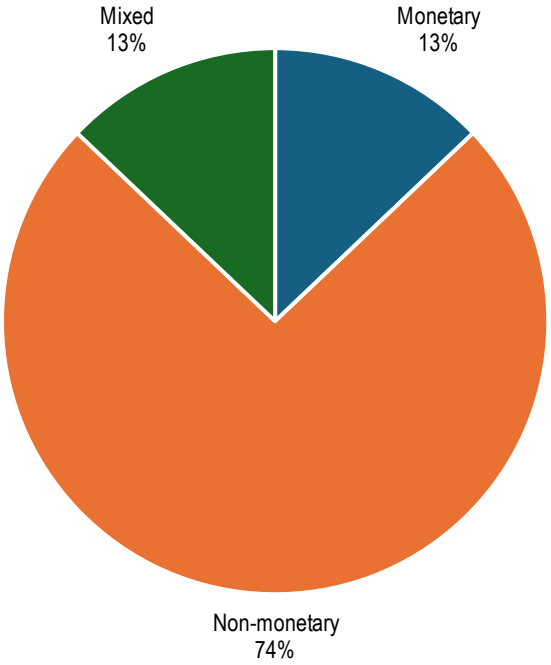

Figure 6: Percentage of articles using monetary, non-monetary and mixed methods

Within monetary and non-monetary methods, this study identified nine methods that researchers used to attach a value to CES. Monetary methods include Willingness to Pay (WTP), benefit/value transfer and market price. Non-monetary methods include survey questionnaire, interview, social media-based methods, focus group discussions, mapping and Q methodology. Survey questionnaire was the most used method in the studies followed by interviews and social media-based methods while participatory mapping, participatory GIS and Q methodology were the least utilized methods (Figure 7). More than half of the studies combined two or more of these methods. For instance, interviews were used to find out how much people were willing to pay for cultural services, information that is key in calculating WTP. In other instances, issues noted in the focus group discussions with key informants were integrated into questionnaires which were administered to key government and non-governmental stakeholders, residents, tourists and indigenous people through household or online surveys.

To improve the quality of data collected, rating process (using a 5-point Likert scale for example) was incorporated in some questionnaires and interviews. The strategy helped to accurately capture how people feel about coastal wetlands' CES by attaching a numerical value to them. Use of local language in questionnaires of some studies also helped to improve the accuracy of data collected.

Mapping method was assisted by using GPS and GIS software (e.g. ArcGIS and Survey123). GPS was used to collect coordinates of CES hotspots while ArcGIS was used for spatial analysis of the study area in relation to CES. Survey123, which is an ArcGIS online tool, was used to create online surveys where respondents would locate CES hotspots and complete a brief questionnaire about the identified sites.

Social media-based methods analysed photos of CES sites uploaded by users of various platforms such as Flickr, Instagram, X (Twitter) and Weibo. In some instances, Integrated Valuation of Ecosystem and Trade-off (InVEST) model was used to analyse preference of CES.

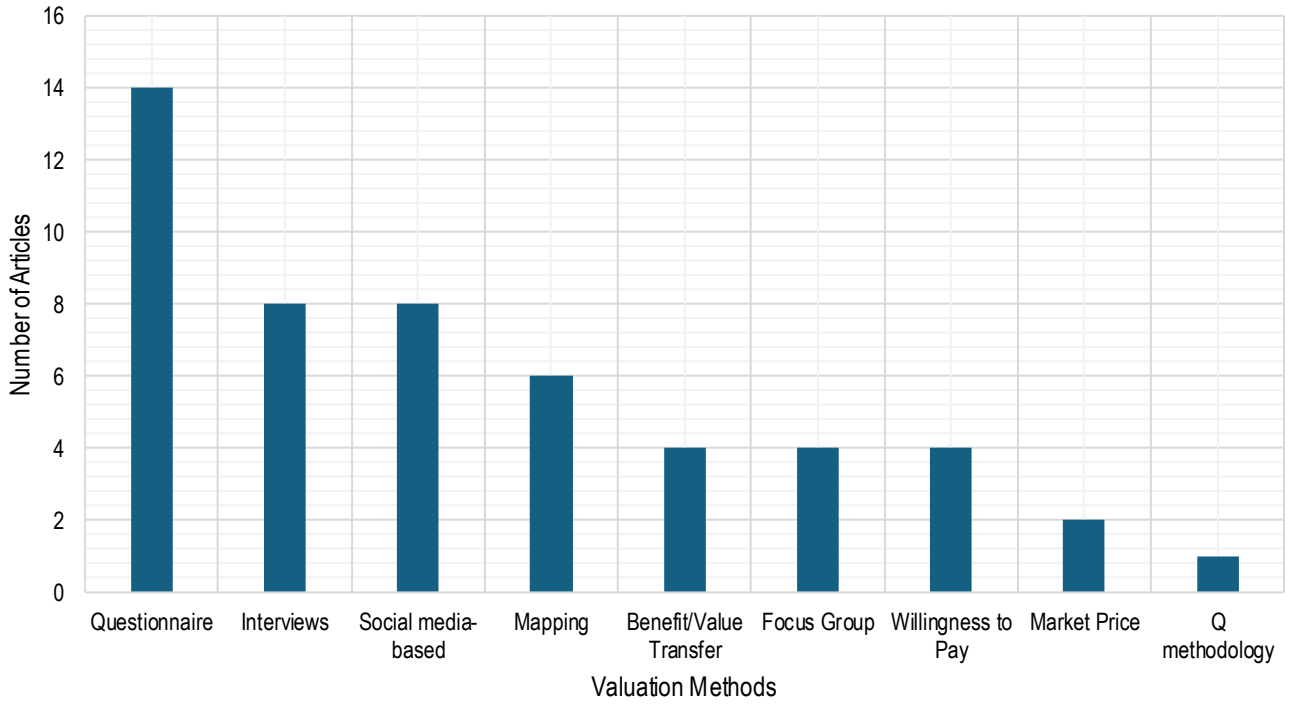

Figure 7: Number of articles using different CES valuation methods

4.5 Valuation Methods in Relation to CES Categories

Figure 9 has 9 bars representing 9 CES valuation methods. Each of the bars shows CES categories that were measured using the corresponding method. Generally, all methods were utilized in measuring recreation and ecotourism services as well as aesthetic values (Appendix 2). At the lower end, benefit/value transfer and market price were used to value three CES categories only which were recreation and tourism services, aesthetic values and cultural heritage values. Questionnaire, interviews and social media-based methods were used to measure all the 10 categories followed by mapping and focus group which measured 9 and 8 categories respectively. In summary non-monetary methods were more utilized than monetary methods.

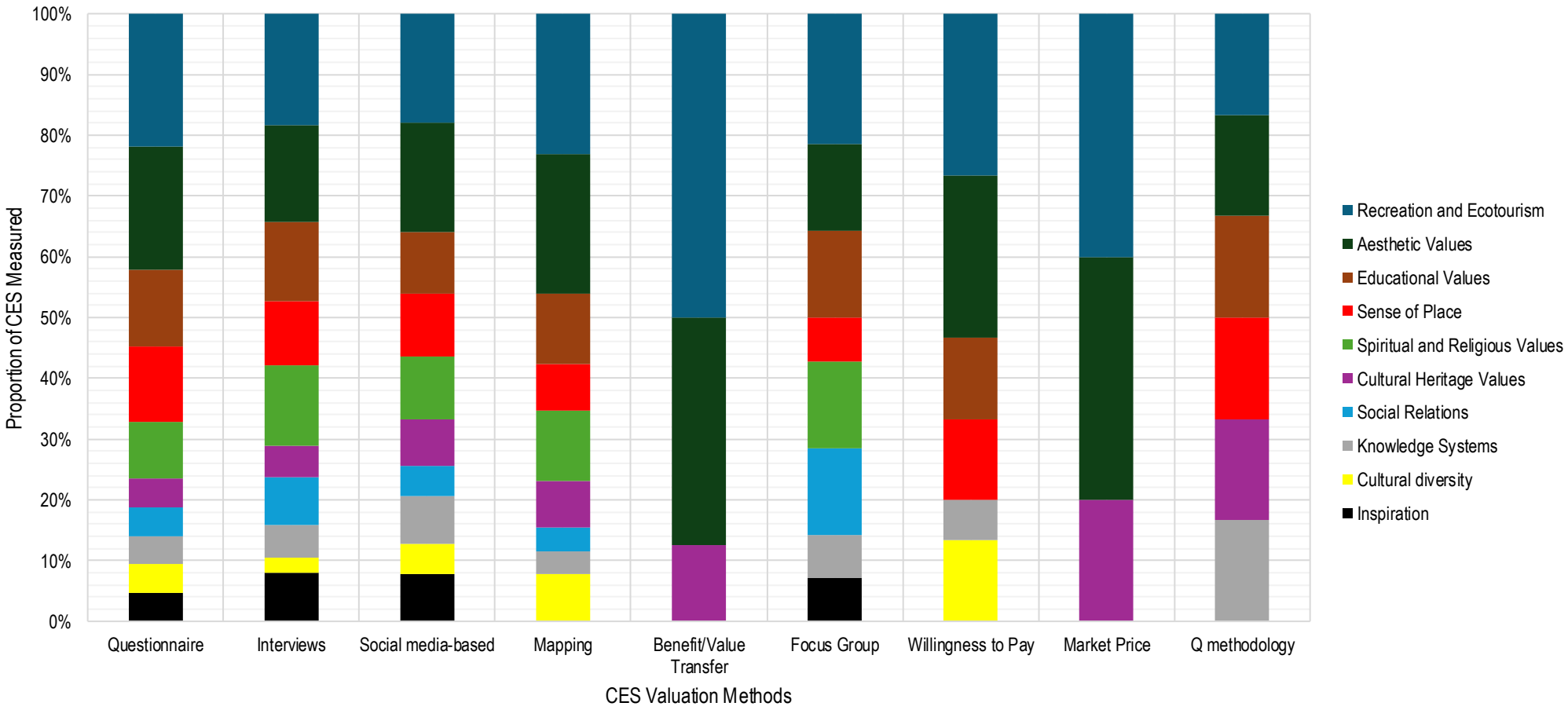

Figure 8: Proportional distribution of CES categories corresponding to valuation methods

5 Discussion

CES reflect the cultural dimension of ES, and their values need to be well captured in the assessment of ES. Understanding how important culture is to the conservation of coastal wetlands would justify the need for its consideration in ES assessment. The systematic literature review used in this study provides an insight on how culture is measured through CES by exploring different methods that researchers used to measure CES. Furthermore, the review gives a clear picture on the extent or frequency of which different CES categories are quantified. This section discusses the key findings of the review and the relevance of culture in coastal wetland protection.

5.1 Frequently measured CES categories

The coastal population access coastal wetlands' CES as a bundle and utilization of one service often depends on the presence of another. For example, the presence of a cultural heritage site can be a source of inspiration for the local communities. This interdependency brings about a problem of double counting when quantifying CES (Cabana et al., 2020). To avoid this problem, some researchers either focus on a single clear category (like recreation) (Cheng et al., 2019) or combining two closely related categories to represent CES while ignoring other categories. The latter was common in the reviewed studies where recreational and ecotourism services were paired with aesthetic values in 26 of the 31 studies. The reason why the two categories are frequently studied is related to the high economic importance of recreation and leisure (in the tourism industry) and aesthetic services to the global economy (Rodrigues Garcia et al., 2017). The other reason is because recreation is easier to quantify in monetary terms compared to other less tangible subcategories like inspiration (Martin et al., 2016). Unsurprisingly, recreational services and aesthetic values were measured using all the identified valuation methods in this study (Figure 8). Unfortunately, overemphasis on recreation and ecotourism and aesthetic value may lead to researchers and policymakers to assume that these represent CES, thereby contributing to an unconscious marginalization of other important CES (Milcu et al., 2013).

5.2 Relevance of culture in protecting coastal wetlands

Culture is a social, communicative and productive process that involves all spheres and spatial scales of life and environmental interaction (Pröpper & Haupts, 2014). To sustain cultural processes, the environment plays an important role of providing a space for cultural practices and generation of cultural benefits, as illustrated by Fish et al (2016). The prolonged human-nature interaction, within the cultural domain, results in humans developing environmental values, beliefs and ethics that shape their attitudes and behaviour towards the environment. Eventually, humans develop a strong connection with the environment and assume the role of environmental stewards for the sake of continued cultural practices.

Coastal wetlands are an example of environmental spaces that provide a platform for cultural practices and foster cultural identities among many ecosystem benefits. This correlates well with the Ramsar Convention (2005) which recognizes the association of wetlands with long-standing cultural practices and a strong cultural connection that local communities and indigenous people have developed over time. This emphasizes the need to integrate culture in protection and sustainable management of coastal wetlands. However, it must be noted that cultural values and beliefs differ among cultural groups and solutions to protect coastal wetlands should not be universal but should consider unique cultural beliefs of a given area, ranging from local to national levels (Pizzirani et al., 2014).

Bearing in mind that research findings could be an important input in gathering support and formulating policies that protect coastal wetlands, the importance of recognizing culture in CES valuation research is demonstrated through different ways. In the reviewed studies, the concept of culture was integrated by prioritizing the local community and indigenous people as primary sources of information when collecting data through questionnaires, interviews, focus group discussions and mapping. These are sections of the community that frequently interact and strongly connect with natural environment, and they are thus better able than outsiders to identify ecosystems services they receive and how they value them (Himes-Cornell et al., 2018). The local communities are 2.2-2.5 times more likely to be associated with cultural services (such as aesthetic appreciation and birdwatching) than outsiders (Ghermandi et al., 2020). Understanding how local communities value coastal wetlands is crucial in gathering public support in advocating for protection of wetlands. In a study by Elwell et al (2020), for example, a participatory mapping of CES was conducted with indigenous communities who perceive the coastal zone as their ancestral territory and are strongly attached to it. Consequently, the study yielded a comprehensive list of ecosystem services and participants identified several aspects of the coastal zone that they consider important to wellbeing and need to be protected.

Researchers have also recognized and embraced culture by using local language as a mode of communication during data collection. Language is one of the symbolic phenomena through which culture is expressed (Satterfield et al., 2013). Out of 31 studies reviewed, two studies by Reyes-Arroyo et al (2021) and Merven et al (2023) used Spanish (in Mexico) and Mauritanian Creole (in Mauritius) respectively in their questionnaires even though the final report of study findings was in English. The questionnaires were administered to the local communities who found it easier to communicate in their own language more than English. Most importantly, this strategy (of using local language) overcomes the language barrier in communication and gives an opportunity for the local communities to freely propose best ways of conserving their natural resources including coastal wetlands.

5.3 Analysis of valuation methods

The study identified six non-monetary methods (also known as social cultural methods) and three monetary methods (also known as economic methods). These methods have their strengths and limitations, and combining two or more methods may improve accuracy of results. Integrating monetary and non-monetary methods could help in obtaining better evaluation of CES (Cheng et al., 2019). This was observed in four of the 31 studies where Willingness to Pay (WTP) was integrated with questionnaire and focus groups to adequately capture the value of CES. The following section will investigate in greater details the valuation methods that were used in the reviewed studies.

Non-monetary or Social cultural methods

These were the commonly used methods in the reviewed studies (figure 6 & 7), and they attempted to capture and measure values, beliefs attitudes and perceptions directly from recipients of CES benefits. Researchers choose these methods because they enumerate a relatively correct value of CES since coastal wetland users are directly involved in data collection.

Interviews, Q methodology, focus group discussions and questionnaires (especially those with open ended questions) allow stakeholders and key informants to freely express their complex, multiple and varied experiences with ecosystem without influence from the assessors (Hirons et al., 2016). Because respondents are free to express their feelings and deep attachment to the coastal wetlands, non-

monetary methods are suitable to measure intangible cultural services that are psychological in nature such as inspiration and spiritual values. In the reviewed articles, non-monetary methods were used to measure all CES categories including those that are more complex and largely depend on one's belief, values and perception such as inspiration and spiritual values (figure 8). For instance, in studies by Dou et al (2021) and Queiroz et al (2017), participants valued CES categories such as inspiration and spiritual values by rating them on a 5-point Likert Scale. The main disadvantage of non-monetary methods is that they are time consuming, and a lot of costs are incurred in training data collectors and reaching out to key stakeholders and community members in the study area. Online surveys, interviews and focus group discussions may help in cutting costs of travelling to places where participants are located.

Participatory mapping is a powerful tool to link the physical features with human perceptions of a place (Cheng et al., 2019). The method involves participation of key stakeholders who identify the spatial distribution of CES in their locations of interest. How CES are identified depends on cultural interaction between stakeholders and the environmental spaces where CES is offered. This will also indicate how much such places are valued by stakeholders. In some cases, many values are concentrated at one place, and this may trigger a conflict of values either between CES and other ES or among CES. Participatory mapping is useful in predicting potential conflict of values (Kobryn et al., 2018; Moore et al., 2017) and help in finding the best solution. Mapping may also integrate statistical models to investigate trade-offs between CES and other ES such as provisioning. In a reviewed study by Chung et al (2015), InVEST (Integrated Valuation of Environmental Services and Trade-offs) model was used to assess and quantify habitat risk and ecosystem services in coastal areas and explore trade-offs among ES. One of the study findings was that aquaculture production (provisioning services) makes coastal zones more vulnerable than recreational activities (cultural services) and this information could be helpful for decision makers to decide on the best land use option.

The social media-based method is another frequently used method in the reviewed research studies. It is a relatively new method but could become an important tool in CES assessment because the use of a relatively small number of free available, spatially explicit photographs can provide a good view of the cultural uses of a site (Cheng et al., 2019; Richards & Friess, 2015). Its main advantage is that it not time consuming and costs less compared to surveys and interviews (Richards & Friess, 2015). According to Hirons et al (2016), the content of crowdsourced, georeferenced, photographic datasets from social media platforms (e.g. Flickr and Instagram) is analysed for evidence of cultural ecosystem service potential. Just like mapping approach, the geolocated nature of images allows spatial patterns in CES uptake to be identified (Hirons et al., 2016). In some reviewed studies, social media-based method was used to measure all the 10 categories of CES with recreation and tourism services and aesthetic values being the mostly measured categories (figure 8). In a study by Cunha et al (2018), social media was combined with the InVEST model to determine the trend in tourists' visits to coastal ecosystems through analysis of photographs uploaded on Flickr. In another study by Havinga et al (2020), social media was deployed to define and spatially quantify CES.

Despite being considered cheaper and less time consuming than other methods, the social media-based approach has been criticized for its bias towards most favoured tourist attractive places. Tourists are likely to upload photographs on their social media platforms to share unique events and situations. This may imply that natural environment in more remote or less frequented locations by tourists may be less suited for analysis (Ghermandi et al., 2020). Secondly, the method has also been criticized for not being

ethical regarding privacy and consent. In a study by Havinga et al (2020), it was not clear whether social media users fully appreciated the extent to which their data could be used and whether they would give permission for it to be used in research studies targeting tourism industry.

Monetary or Economic Methods

The study found that only three monetary methods were used to measure CES i.e. Willingness to Pay (WTP), benefit/value transfer and market price (Figure 7). Benefit/value transfer and market price were used to measure only three CES categories which were recreation, aesthetic values and cultural heritage values while WTP was used to measure cultural diversity, knowledge systems, sense of place, educational values, aesthetic values and recreation (Figure 8). However, some of CES categories (such as cultural heritage, knowledge systems, sense of place, educational values, spiritual values, social relations and inspiration) have intangible value, and their valuation depends on one's belief, attitude and values hence making it difficult to attach an economic value to them. This is why non-monetary methods were preferred to measure these categories. A reviewed study by Gaglio et al (2024) found that intangible values are determined by travel distance, professional categories and future use, and these should be factored in when determining value of intangible services. For example, people whose profession is inclined towards environmental management will be willing to pay more for conservation of coastal wetlands than those outside the profession.

According to Cheng et al (2019), monetary methods are used in the final calculation of CES's economic value through a process that shows great potential for accurate evaluation. However, to produce sound information, the method needs skilled researchers who are familiar with all the processes and techniques involved in calculating the economic value. In addition to that it is difficult to find the market value of some intangible services (such as sense of place) which means they get excluded from the ES framework (Cheng et al., 2019).

Benefit/value transfer has been criticized for valuing the CES of one area based on values from another location. In other words, it means applying values of a community to another community in a different ecological, economic and social context. Cultural values are very context specific and can change greatly from one community or context to another depending on how the ecosystem is used (Satterfield et al., 2013). Transferring values between different context can lead to inaccurate valuation. As Himes-Cornell et al posit "If an ecosystem service is not valuable to those that use or could use it in one location or context, then applying a value calculated for another region will likely overinflate the calculated value" (Emerton, 2014 cited in Himes-Cornell et al, 2018, p.10).It can also lead to underestimation of the CES of the transferred region.

5.4 Study findings' implications on protection and management of coastal wetlands

Adequate valuation of CES ensures that cultural services are not overvalued and undervalued in the assessment of ES. CES value will play a crucial role in influencing decisions regarding protection and management of coastal wetlands. If policymakers have accurate information on the importance of coastal wetlands and how the public values it, CES may not be traded-off with other ES and conservation of coastal wetlands could be prioritized. Eventually, degraded wetlands could be restored and policies on protection of the sites would be formulated.

To capture a more accurate value of CES, researchers should use more than one method of measuring CES as reflected in more than half of the reviewed studies. Preferably, monetary and non-monetary methods should complement each other to capture both the economic and intangible value of CES. Secondly, research studies should recognize the importance of other cultural services not just recreational services. This will ensure that CES is well represented in ES assessment not as a single service but as a bundle of services that are interdependent on each other. Eventually, the problem of CES overvaluation or undervaluation will be corrected.

6 Conclusion

Research studies on valuation of CES associated with coastal wetlands have been conducted every year since 2015. The studies aim at capturing value of culture embedded in CES using monetary and non-monetary methods or combination of both. Among a wide range of CES categories, most researchers have emphasized on recreational services and aesthetic values as a representation of CES, a development that may result into undervaluation of CES in ES assessment. On valuation methods used, non-monetary methods (more especially open-ended questionnaires) dominated more than monetary methods while other studies used both methods. Non-monetary methods have the capacity to capture intangible cultural services that are psychological in nature and hence, are difficult to attach an economic value to. These methods give respondents freedom to express their feelings, experiences and deep attachment to the ecosystem which may sometimes be reflected in the way they rate or rank CES categories. However, to improve the accuracy of CES value, there is need to measure CES as a bundle of services and combine monetary and non-monetary methods of valuation. A more accurate CES value will ensure adequate presentation of CES in assessment of ES which eventually may influence policy on conservation of coastal wetlands.

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8. Appendix

Appendix 1: List of reviewed articles

No.	Authors	Title	Year	Country	Full Citation
1	Boeri M.; Stojanovic T.A.; Wright L.J.; Burton N.H.K.; Hockley N.; Bradbury R.B.	Public preferences for multiple dimensions of bird biodiversity at the coast: insights for the cultural ecosystem services framework	2020	UK	Boeri, M., Stojanovic, T. A., Wright, L. J., Burton, N. H. K., Hockley, N., & Bradbury, R. B. (2020). Public preferences for multiple dimensions of bird biodiversity at the coast: insights for the cultural ecosystem services framework [Article]. *Estuarine, Coastal and Shelf Science*, *235*, Article 106571. https://doi.org/10.1016/j.ecss.2019.106571
2	Brown G.; Hausner V.H.	An empirical analysis of cultural ecosystem values in coastal landscapes	2017	Global	Brown, G., & Hausner, V. H. (2017). An empirical analysis of cultural ecosystem values in coastal landscapes [Article]. *Ocean and Coastal Management*, *142*, 49-60. https://doi.org/10.1016/j.ocecoaman.2017.03.019
3	Cabana D.; Ryfield F.; Crowe T.P.; Brannigan J.	Evaluating and communicating cultural ecosystem services	2020	Ireland	Cabana, D., Ryfield, F., Crowe, T. P., & Brannigan, J. (2020). Evaluating and communicating cultural ecosystem services [Article]. *Ecosystem Services*, *42*, Article 101085. https://doi.org/10.1016/j.ecoser.2020.101085
4	Chung M.G.; Kang H.; Choi S.-U	Assessment of coastal ecosystem services for conservation strategies in South Korea	2015	South Korea	Chung, M. G., Kang, H., & Choi, S. U. (2015). Assessment of coastal ecosystem services for conservation strategies in South Korea [Article]. *PLoS ONE*, *10*(7), Article 0133856. https://doi.org/10.1371/journal.pone.0133856
5	Clarke B.; Thet A.K.; Sandhu H.; Dittmann S.	Integrating Cultural Ecosystem Services valuation into coastal wetlands restoration: A case study from South Australia	2021	Australia	Clarke, B., Thet, A. K., Sandhu, H., & Dittmann, S. (2021). Integrating Cultural Ecosystem Services valuation into coastal wetlands restoration: A case study from South Australia [Article]. *Environmental Science and Policy*, *116*, 220-229. https://doi.org/10.1016/j.envsci.2020.11.014
6	Cunha J.; Elliott M.; Ramos S.	Linking modelling and empirical data to assess recreation services provided by coastal habitats: The case of NW Portugal	2018	Portugal	Cunha, J., Elliott, M., & Ramos, S. (2018). Linking modelling and empirical data to assess recreation services provided by coastal habitats: The case of NW Portugal [Article]. *Ocean and Coastal Management*, *162*, 60-70. https://doi.org/10.1016/j.ocecoaman.2017.12.022

7	Dou Y.; Liu M.; Bakker M.; Yu X.; Carsjens G.J.; De Groot R.; Liu J.	Influence of human interventions on local perceptions of cultural ecosystem services provided by coastal landscapes: Case study of the Huiwen wetland, southern China	2021	China	Dou, Y., Liu, M., Bakker, M., Yu, X., Carsjens, G. J., De Groot, R., & Liu, J. (2021). Influence of human interventions on local perceptions of cultural ecosystem services provided by coastal landscapes: Case study of the Huiwen wetland, southern China [Article]. *Ecosystem Services*, *50*, Article 101311. https://doi.org/10.1016/j.ecoser.2021.101311
8	Elwell T.L.; López-Carr D.; Gelcich S.; Gaines S.D.	The importance of cultural ecosystem services in natural resource-dependent communities: Implications for management	2020	Chile	Elwell, T. L., López-Carr, D., Gelcich, S., & Gaines, S. D. (2020). The importance of cultural ecosystem services in natural resource-dependent communities: Implications for management [Article]. *Ecosystem Services*, *44*, Article 101123. https://doi.org/10.1016/j.ecoser.2020.101123
9	Filho L.M.; Roebeling P.; Villasante S.; Bastos M.I.	Ecosystem services values and changes across the Atlantic coastal zone: Considerations and implications	2022	Global	Filho, L. M., Roebeling, P., Villasante, S., & Bastos, M. I. (2022). Ecosystem services values and changes across the Atlantic coastal zone: Considerations and implications [Article]. *Marine Policy*, *145*, Article 105265. https://doi.org/10.1016/j.marpol.2022.105265
10	Gaglio M.; Lanzoni M.; Muresan A.N.; Schirpke U.; Castaldelli G.	Quantifying intangible values of wetlands as instrument for conservation in the Po delta park (Italy)	2024	Italy	Gaglio, M., Lanzoni, M., Muresan, A. N., Schirpke, U., & Castaldelli, G. (2024). Quantifying intangible values of wetlands as instrument for conservation in the Po delta park (Italy) [Article]. *Journal of Environmental Management*, *360*, Article 121227. https://doi.org/10.1016/j.jenvman.2024.121227
11	Havinga I.; Bogaart P.W.; Hein L.; Tuia D.	Defining and spatially modelling cultural ecosystem services using crowdsourced data	2020	Netherlands	Havinga, I., Bogaart, P. W., Hein, L., & Tuia, D. (2020). Defining and spatially modelling cultural ecosystem services using crowdsourced data [Article]. *Ecosystem Services*, *43*, Article 101091. https://doi.org/10.1016/j.ecoser.2020.101091
12	Kobryn H.T.; Brown G.; Munro J.; Moore S.A.	Cultural ecosystem values of the Kimberley coastline: An empirical analysis with implications for coastal and marine policy	2018	Australia	Kobryn, H. T., Brown, G., Munro, J., & Moore, S. A. (2018). Cultural ecosystem values of the Kimberley coastline: An empirical analysis with implications for coastal and marine policy [Article]. *Ocean and Coastal Management*, *162*, 71-84. https://doi.org/10.1016/j.ocecoaman.2017.09.002
13	Marshall N.A.; Dunstan P.; Pert P.; Thiault L.	How people value different ecosystems within the Great Barrier Reef	2019	Australia	Marshall, N. A., Dunstan, P., Pert, P., & Thiault, L. (2019). How people value different ecosystems within the Great Barrier Reef [Article]. *Journal of Environmental Management*, *243*, 39-44. https://doi.org/10.1016/j.jenvman.2019.05.024

14	Merven R.; Appadoo C.; Florens F.B.V.; Iranah P.	Dependency on Mangroves Ecosystem Services is Modulated by Socioeconomic Drivers and Socio-Ecological Changes – Insights From a Small Oceanic island	2023	Mauritius	Merven, R., Appadoo, C., Florens, F. B. V., & Iranah, P. (2023). Dependency on Mangroves Ecosystem Services is Modulated by Socioeconomic Drivers and Socio-Ecological Changes – Insights From a Small Oceanic island [Article]. *Human Ecology*, *51*(6), 1141-1156. https://doi.org/10.1007/s10745-023-00464-3
15	Mouttaki I.; Bagdanavičiūtė I.; Maanan M.; Erraiss M.; Rhinane H.; Maanan M.	Classifying and Mapping Cultural Ecosystem Services Using Artificial Intelligence and Social Media Data	2022	Lithunia	Mouttaki, I., Bagdanavičiūtė, I., Maanan, M., Erraiss, M., Rhinane, H., & Maanan, M. (2022). Classifying and Mapping Cultural Ecosystem Services Using Artificial Intelligence and Social Media Data [Article]. *Wetlands*, *42*(7), Article 86. https://doi.org/10.1007/s13157-022-01616-9
16	Mouttaki I.; Khomalli Y.; Maanan M.; Bagdanavičiūtė I.; Rhinane H.; Kuriqi A.; Pham Q.B.; Maanan M.	A new approach to mapping cultural ecosystem services	2021	Morocco	Mouttaki, I., Khomalli, Y., Maanan, M., Bagdanavičiūtė, I., Rhinane, H., Kuriqi, A., Pham, Q. B., & Maanan, M. (2021). A new approach to mapping cultural ecosystem services [Article]. *Environments - MDPI*, *8*(6), Article 56. https://doi.org/10.3390/environments8060056
17	Oleson K.L.L.; Barnes M.; Brander L.M.; Oliver T.A.; Van Beek I.; Zafindrasilivonona B.; Van Beukering P.	Cultural bequest values for ecosystem service flows among indigenous fishers: A discrete choice experiment validated with mixed methods	2015	Madagascar	Oleson, K. L. L., Barnes, M., Brander, L. M., Oliver, T. A., Van Beek, I., Zafindrasilivonona, B., & Van Beukering, P. (2015). Cultural bequest values for ecosystem service flows among indigenous fishers: A discrete choice experiment validated with mixed methods [Article]. *Ecological Economics*, *114*, 104-116. https://doi.org/10.1016/j.ecolecon.2015.02.028
18	Pueyo-Ros J.; Ribas A.; Fraguell R.M.	A cultural approach to wetlands restoration to assess its public acceptance	2019	Spain	Pueyo-Ros, J., Ribas, A., & Fraguell, R. M. (2019). A cultural approach to wetlands restoration to assess its public acceptance [Article]. *Restoration Ecology*, *27*(3), 626-637. https://doi.org/10.1111/rec.12896
19	Queiroz L.D.S.; Rossi S.; Calvet-Mir L.; Ruiz-Mallén I.; García-Betorz S.; Salvà-Prat J.; Meireles A.J.D.A.	Neglected ecosystem services: Highlighting the socio-cultural perception of mangroves in decision-making processes	2017	Brazil	Queiroz, L. D. S., Rossi, S., Calvet-Mir, L., Ruiz-Mallén, I., García-Betorz, S., Salvà-Prat, J., & Meireles, A. J. D. A. (2017). Neglected ecosystem services: Highlighting the socio-cultural perception of mangroves in decision-making processes [Article]. *Ecosystem Services*, *26*, 137-145. https://doi.org/10.1016/j.ecoser.2017.06.013

20	Reyes-Arroyo N.; Camacho-Valdez V.; Saenz-Arroyo A.; Infante-Mata D.	Socio-cultural analysis of ecosystem services provided by mangroves in La Encrucijada Biosphere Reserve, southeastern Mexico	2021	Mexico	Reyes-Arroyo, N., Camacho-Valdez, V., Saenz-Arroyo, A., & Infante-Mata, D. (2021). Socio-cultural analysis of ecosystem services provided by mangroves in La Encrucijada Biosphere Reserve, southeastern Mexico [Article]. *Local Environment*, *26*(1), 86-109. https://doi.org/10.1080/13549839.2020.1867836
21	Sangha K.K.; Stoeckl N.; Crossman N.; Costanza R.	A state-wide economic assessment of coastal and marine ecosystem services to inform sustainable development policies in the Northern Territory, Australia	2019	Australia	Sangha, K. K., Stoeckl, N., Crossman, N., & Costanza, R. (2019). A state-wide economic assessment of coastal and marine ecosystem services to inform sustainable development policies in the Northern Territory, Australia [Article]. *Marine Policy*, *107*, Article 103595. https://doi.org/10.1016/j.marpol.2019.103595
22	Sannigrahi S.; Chakraborti S.; Joshi P.K.; Keesstra S.; Sen S.; Paul S.K.; Kreuter U.; Sutton P.C.; Jha S.; Dang K.B.	Ecosystem service value assessment of a natural reserve region for strengthening protection and conservation	2019	India	Sannigrahi, S., Chakraborti, S., Joshi, P. K., Keesstra, S., Sen, S., Paul, S. K., Kreuter, U., Sutton, P. C., Jha, S., & Dang, K. B. (2019). Ecosystem service value assessment of a natural reserve region for strengthening protection and conservation [Article]. *Journal of Environmental Management*, *244*, 208-227. https://doi.org/10.1016/j.jenvman.2019.04.095
23	Soy-Massoni E.; Langemeyer J.; Varga D.; Sáez M.; Pintó J.	The importance of ecosystem services in coastal agricultural landscapes: Case study from the Costa Brava, Catalonia	2016	Spain	Soy-Massoni, E., Langemeyer, J., Varga, D., Sáez, M., & Pintó, J. (2016). The importance of ecosystem services in coastal agricultural landscapes: Case study from the Costa Brava, Catalonia [Article]. *Ecosystem Services*, *17*, 43-52. https://doi.org/10.1016/j.ecoser.2015.11.004
24	Thiagarajah J.; Wong S.K.M.; Richards D.R.; Friess D.A.	Historical and contemporary cultural ecosystem service values in the rapidly urbanizing city state of Singapore	2015	Singapore	Thiagarajah, J., Wong, S. K. M., Richards, D. R., & Friess, D. A. (2015). Historical and contemporary cultural ecosystem service values in the rapidly urbanizing city state of Singapore [Article]. *Ambio*, *44*(7), 666-677. https://doi.org/10.1007/s13280-015-0647-7
25	Thoya P.; Owuor M.A.; von Thenen M.; Omukoto J.O.	Variations in community perceptions of ecosystem services within the Tana River estuary, Kenya: Implications for ocean governance	2022	Kenya	Thoya, P., Owuor, M. A., von Thenen, M., & Omukoto, J. O. (2022). Variations in community perceptions of ecosystem services within the Tana River estuary, Kenya: Implications for ocean governance [Article]. *Western Indian Ocean Journal of*

					Marine Science, *2022*(1 Special Issue), 47-57. https://doi.org/10.4314/wiojms.si2022.1.4
26	Toledo D.; Briceño T.; Ospina G.	Ecosystem service valuation framework applied to a legal case in the Anchicaya region of Colombia	2018	Colombia	Toledo, D., Briceño, T., & Ospina, G. (2018). Ecosystem service valuation framework applied to a legal case in the Anchicaya region of Colombia [Article]. *Ecosystem Services*, *29*, 352-359. https://doi.org/10.1016/j.ecoser.2017.02.022
27	Veidemane K.; Reke A.; Ruskule A.; Vinogradovs I.	Assessment of Coastal Cultural Ecosystem Services and Well-Being for Integrating Stakeholder Values into Coastal Planning	2024	Latvia	Veidemane, K., Reke, A., Ruskule, A., & Vinogradovs, I. (2024). Assessment of Coastal Cultural Ecosystem Services and Well-Being for Integrating Stakeholder Values into Coastal Planning [Article]. *Land*, *13*(3), Article 362. https://doi.org/10.3390/land13030362
28	Wainger L.; McMurray A.; Paolisso M.; Johnson K.J.; Needelman B.	Coastal Community Values for Marsh-Dependent Socioecological Services Revealed through a Systematic Qualitative Approach	2017	USA	Wainger, L., McMurray, A., Paolisso, M., Johnson, K. J., & Needelman, B. (2017). Coastal Community Values for Marsh-Dependent Socioecological Services Revealed through a Systematic Qualitative Approach [Article]. *Agricultural and Resource Economics Review*, *46*(2), 338-364. https://doi.org/10.1017/age.2017.15
29	Wang W.; Wu C.; Fang Q.; Harrison O.I.	Cultural ecosystem services evaluation in a coastal city of China using social media data	2023	China	Wang, W., Wu, C., Fang, Q., & Harrison, O. I. (2023). Cultural ecosystem services evaluation in a coastal city of China using social media data [Article]. *Ocean and Coastal Management*, *242*, Article 106693. https://doi.org/10.1016/j.ocecoaman.2023.106693
30	Zhao Q.; Chen Y.; Gone K.P.; Wells E.; Margeson K.; Sherren K.	Modelling cultural ecosystem services in agricultural dykelands and tidal wetlands to inform coastal infrastructure decisions: A social media data approach	2023	Canada	Zhao, Q., Chen, Y., Gone, K. P., Wells, E., Margeson, K., & Sherren, K. (2023). Modelling cultural ecosystem services in agricultural dykelands and tidal wetlands to inform coastal infrastructure decisions: A social media data approach [Article]. *Marine Policy*, *150*, Article 105533. https://doi.org/10.1016/j.marpol.2023.105533
31	Zunino S.; Melaku Canu D.; Marangon F.; Troiano S.	Cultural Ecosystem Services Provided by Coralligenous Assemblages and Posidonia oceanica in the Italian Seas	2020	Italy	Zunino, S., Melaku Canu, D., Marangon, F., & Troiano, S. (2020). Cultural Ecosystem Services Provided by Coralligenous Assemblages and Posidonia oceanica in the Italian Seas [Article]. *Frontiers in Marine Science*, *6*, Article 823. https://doi.org/10.3389/fmars.2019.00823

Appendix 2: CES Valuation Methods for Reviewed Articles

No.	Full Citation	CES Category										Method to Measure CES
		Cultural diversity	*Spiritual and Religious Values*	*Knowledge Systems*	*Educational Values*	*Inspiration*	*Aesthetic Values*	*Social Relations*	*Sense of Place*	*Cultural Heritage Values*	*Recreation and Ecotourism*	
1	Boeri, M., Stojanovic, T. A., Wright, L. J., Burton, N. H. K., Hockley, N., & Bradbury, R. B. (2020). Public preferences for multiple dimensions of bird biodiversity at the coast: insights for the cultural ecosystem services framework [Article]. Estuarine, Coastal and Shelf Science, 235, Article 106571. https://doi.org/10.1016/j.ecss.2019.106571						X				X	Willingness to Pay (WTP), FGD & online questionnaire
2	Brown, G., & Hausner, V. H. (2017). An empirical analysis of cultural ecosystem values in coastal landscapes [Article]. Ocean and Coastal Management, 142, 49-60. https://doi.org/10.1016/j.ocecoaman.2017.03.019		X		X		X	X		X	X	Mapping (PPGIS)
3	Cabana, D., Ryfield, F., Crowe, T. P., & Brannigan, J. (2020). Evaluating and communicating cultural ecosystem services [Article]. Ecosystem Services, 42, Article 101085. https://doi.org/10.1016/j.ecoser.2020.101085			X	X		X		X		X	Interview, Mapping (PPGIS), Face-to-face and online survey questionnaire, social media-based
4	Chung, M. G., Kang, H., & Choi, S. U. (2015). Assessment of coastal ecosystem services for conservation strategies in South Korea [Article]. PLoS ONE, 10(7), Article 0133856. https://doi.org/10.1371/journal.pone.0133856						X				X	Mapping (PPGIS)

5	Clarke, B., Thet, A. K., Sandhu, H., & Dittmann, S. (2021). Integrating Cultural Ecosystem Services valuation into coastal wetlands restoration: A case study from South Australia [Article]. Environmental Science and Policy, 116, 220-229. https://doi.org/10.1016/j.envsci.2020.11.014		X		X		X	X	X		X	Online and face-to-face survey questionnaire
6	Cunha, J., Elliott, M., & Ramos, S. (2018). Linking modelling and empirical data to assess recreation services provided by coastal habitats: The case of NW Portugal [Article]. Ocean and Coastal Management, 162, 60-70. https://doi.org/10.1016/j.ocecoaman.2017.12.022										X	Social media based
7	Dou, Y., Liu, M., Bakker, M., Yu, X., Carsjens, G. J., De Groot, R., & Liu, J. (2021). Influence of human interventions on local perceptions of cultural ecosystem services provided by coastal landscapes: Case study of the Huiwen wetland, southern China [Article]. Ecosystem Services, 50, Article 101311. https://doi.org/10.1016/j.ecoser.2021.101311		X		X	X	X	X	X	X	X	Survey questionnaire, interviews
8	Elwell, T. L., López-Carr, D., Gelcich, S., & Gaines, S. D. (2020). The importance of cultural ecosystem services in natural resource-dependent communities: Implications for management [Article]. Ecosystem Services, 44, Article 101123. https://doi.org/10.1016/j.ecoser.2020.101123	X	X				X				X	Mapping (Participatory mapping), interviews, survey questionnaire
9	Filho, L. M., Roebeling, P., Villasante, S., & Bastos, M. I. (2022). Ecosystem services values and changes across the Atlantic coastal zone: Considerations and implications [Article]. Marine Policy, 145, Article 105265. https://doi.org/10.1016/j.marpol.2022.105265						X				X	Benefit/value transfer

10	Gaglio, M., Lanzoni, M., Muresan, A. N., Schirpke, U., & Castaldelli, G. (2024). Quantifying intangible values of wetlands as instrument for conservation in the Po delta park (Italy) [Article]. Journal of Environmental Management, 360, Article 121227. https://doi.org/10.1016/j.jenvman.2024.121227	X			X		X		X		X	Online survey questionnaire, Willingness to pay (WTP)
11	Havinga, I., Bogaart, P. W., Hein, L., & Tuia, D. (2020). Defining and spatially modelling cultural ecosystem services using crowdsourced data [Article]. Ecosystem Services, 43, Article 101091. https://doi.org/10.1016/j.ecoser.2020.101091						X					Social Media-based
12	Kobryn, H. T., Brown, G., Munro, J., & Moore, S. A. (2018). Cultural ecosystem values of the Kimberley coastline: An empirical analysis with implications for coastal and marine policy [Article]. Ocean and Coastal Management, 162, 71-84. https://doi.org/10.1016/j.ocecoaman.2017.09.002	X	X		X		X		X		X	Mapping (PPGIS)
13	Marshall, N. A., Dunstan, P., Pert, P., & Thiault, L. (2019). How people value different ecosystems within the Great Barrier Reef [Article]. Journal of Environmental Management, 243, 39-44. https://doi.org/10.1016/j.jenvman.2019.05.024						X				X	Interviews
14	Merven, R., Appadoo, C., Florens, F. B. V., & Iranah, P. (2023). Dependency on Mangroves Ecosystem Services is Modulated by Socioeconomic Drivers and Socio-Ecological Changes – Insights From a Small Oceanic island [Article]. Human Ecology, 51(6), 1141-1156. https://doi.org/10.1007/s10745-023-00464-3										X	Survey questionnaire
15	Mouttaki, I., Bagdanavičiūtė, I., Maanan, M., Erraiss, M., Rhinane, H., & Maanan, M. (2022). Classifying and Mapping Cultural Ecosystem Services Using Artificial Intelligence and Social Media Data [Article]. Wetlands, 42(7), Article 86. https://doi.org/10.1007/s13157-022-01616-9		X				X				X	Social media-based (Flickr)

16	Mouttaki, I., Khomalli, Y., Maanan, M., Bagdanavičiūtė, I., Rhinane, H., Kuriqi, A., Pham, Q. B., & Maanan, M. (2021). A new approach to mapping cultural ecosystem services [Article]. Environments - MDPI, 8(6), Article 56. https://doi.org/10.3390/environments8060056						X				X	Social media-based (Flickr)
17	Oleson, K. L. L., Barnes, M., Brander, L. M., Oliver, T. A., Van Beek, I., Zafindrasilivonona, B., & Van Beukering, P. (2015). Cultural bequest values for ecosystem service flows among indigenous fishers: A discrete choice experiment validated with mixed methods [Article]. Ecological Economics, 114, 104-116. https://doi.org/10.1016/j.ecolecon.2015.02.028							X	X			Focus group, interviews
18	Pueyo-Ros, J., Ribas, A., & Fraguell, R. M. (2019). A cultural approach to wetlands restoration to assess its public acceptance [Article]. Restoration Ecology, 27(3), 626-637. https://doi.org/10.1111/rec.12896						X		X		X	Survey questionnaire
19	Queiroz, L. D. S., Rossi, S., Calvet-Mir, L., Ruiz-Mallén, I., García-Betorz, S., Salvà-Prat, J., & Meireles, A. J. D. A. (2017). Neglected ecosystem services: Highlighting the socio-cultural perception of mangroves in decision-making processes [Article]. Ecosystem Services, 26, 137-145. https://doi.org/10.1016/j.ecoser.2017.06.013		X	X	X	X	X	X			X	Survey questionnaire, interviews, Focus group
20	Reyes-Arroyo, N., Camacho-Valdez, V., Saenz-Arroyo, A., & Infante-Mata, D. (2021). Socio-cultural analysis of ecosystem services provided by mangroves in La Encrucijada Biosphere Reserve, southeastern Mexico [Article]. Local Environment, 26(1), 86-109. https://doi.org/10.1080/13549839.2020.1867836		X		X		X		X		X	Survey questionnaire

21	Sangha, K. K., Stoeckl, N., Crossman, N., & Costanza, R. (2019). A state-wide economic assessment of coastal and marine ecosystem services to inform sustainable development policies in the Northern Territory, Australia [Article]. Marine Policy, 107, Article 103595. https://doi.org/10.1016/j.marpol.2019.103595						X			X	X	Market price Benefit/value transfer
22	Sannigrahi, S., Chakraborti, S., Joshi, P. K., Keesstra, S., Sen, S., Paul, S. K., Kreuter, U., Sutton, P. C., Jha, S., & Dang, K. B. (2019). Ecosystem service value assessment of a natural reserve region for strengthening protection and conservation [Article]. Journal of Environmental Management, 244, 208-227. https://doi.org/10.1016/j.jenvman.2019.04.095										X	Benefit/value transfer
23	Soy-Massoni, E., Langemeyer, J., Varga, D., Sáez, M., & Pintó, J. (2016). The importance of ecosystem services in coastal agricultural landscapes: Case study from the Costa Brava, Catalonia [Article]. Ecosystem Services, 17, 43-52. https://doi.org/10.1016/j.ecoser.2015.11.004	X			X		X				X	Survey questionnaire, Willingness to Pay (WTP)
24	Thiagarajah, J., Wong, S. K. M., Richards, D. R., & Friess, D. A. (2015). Historical and contemporary cultural ecosystem service values in the rapidly urbanizing city state of Singapore [Article]. Ambio, 44(7), 666-677. https://doi.org/10.1007/s13280-015-0647-7		X		X	X	X		X	X	X	Survey questionnaire, social media (Flickr), interviews
25	Thoya, P., Owuor, M. A., von Thenen, M., & Omukoto, J. O. (2022). Variations in community perceptions of ecosystem services within the Tana River estuary, Kenya: Implications for ocean governance [Article]. Western Indian Ocean Journal of Marine Science, 2022(1 Special Issue), 47-57. https://doi.org/10.4314/wiojms.si2022.1.4		X		X						X	Interviews, Focus group discussion

26	Toledo, D., Briceño, T., & Ospina, G. (2018). Ecosystem service valuation framework applied to a legal case in the Anchicaya region of Colombia [Article]. Ecosystem Services, 29, 352-359. https://doi.org/10.1016/j.ecoser.2017.02.022						X				X	Market price, Benefit/Value transfer
27	Veidemane, K., Reke, A., Ruskule, A., & Vinogradovs, I. (2024). Assessment of Coastal Cultural Ecosystem Services and Well-Being for Integrating Stakeholder Values into Coastal Planning [Article]. Land, 13(3), Article 362. https://doi.org/10.3390/land13030362						X			X	X	Survey questionnaire, Mapping (PGIS)
28	Wainger, L., McMurray, A., Paolisso, M., Johnson, K. J., & Needelman, B. (2017). Coastal Community Values for Marsh-Dependent Socioecological Services Revealed through a Systematic Qualitative Approach [Article]. Agricultural and Resource Economics Review, 46(2), 338-364. https://doi.org/10.1017/age.2017.15			X	X		X		X	X	X	Q Methodology
29	Wang, W., Wu, C., Fang, Q., & Harrison, O. I. (2023). Cultural ecosystem services evaluation in a coastal city of China using social media data [Article]. Ocean and Coastal Management, 242, Article 106693. https://doi.org/10.1016/j.ocecoaman.2023.106693	X	X	X	X	X	X	X	X	X	X	Social media-based
30	Zhao, Q., Chen, Y., Gone, K. P., Wells, E., Margeson, K., & Sherren, K. (2023). Modelling cultural ecosystem services in agricultural dykelands and tidal wetlands to inform coastal infrastructure decisions: A social media data approach [Article]. Marine Policy, 150, Article 105533. https://doi.org/10.1016/j.marpol.2023.105533	X	X	X	X	X	X	X	X	X	X	Social media-based

31	Zunino, S., Melaku Canu, D., Marangon, F., & Troiano, S. (2020). Cultural Ecosystem Services Provided by Coralligenous Assemblages and Posidonia oceanica in the Italian Seas [Article]. Frontiers in Marine Science, 6, Article 823. https://doi.org/10.3389/fmars.2019.00823			X			X		X		X	Online survey questionnaire, Willingness to Pay (WTP)