

Preface

Sediment Fluxes: Natural and Anthropogenic Changes in Coastal Areas at Various Spatial and Temporal Scales

The world's coastal area is a long narrowed feature of mainland, island and adjacent seas denoting a zone of transition between land and ocean. If we consider a world coastal band 20 km wide, we can compute that this area represents nearly 4 % of total Earth surface. Nearly 30 % of people in the world live in this relatively small but highly valued and highly dynamic area. Humans have lived in the coastal area for millennia utilising its many and rich resources for their survival and socio-economic benefit.

Sedimentary processes occurring along coastal areas are a very complex issue and result from the interaction between deep processes (tectonics with subsidence/uplift) and superficial processes (climate, sea level change and hydrodynamic) (Cloetingh 2007). The pattern and distribution of sedimentary facies in depositional basins are under sediment fluxes control (Jones and Frostick 2002).

Coastal processes and natural ecosystems are subject to changes that vary greatly in geographic scales, timing and duration, combining to create dynamic and biologically productive coastal systems vulnerable to additional pressures resulting from human activities (Dean 2004). In turn, the sustainability of human economic and social hazards can be seen as a result of our poor understanding of the dynamics of land-ocean interactions, coastal processes and influence of poorly planned and managed human interventions (Crossland et al. 2007). Indeed a major problem for coastal studies is the constant changing coastal systems, from both natural and human causes (Maanan & Robin 2010). Changing wave and current regimes, climate, morphological processes and fluxes of materials from land, atmosphere and oceans are causes of high natural variabilities, which are still imperfectly understood. Moreover, major questions remain unanswered such as sedimentary fluxes quantification and precise models of both solid matter transport from source-to-sink areas and their consequences on building sedimentary architecture of continental shelf at various spatial scales (Milliman and Farnsworth 2011).

Conditions of erosion, timing and processes of sedimentary deposition and preservation as a function of environmental, climatic conditions and with human interplay are still a challenge in science (Anthony 2009).

Land-ocean sediment fluxes are one of the most important components in the sediment cycle of the Earth system and are also a major influencing factor in the processes of land-ocean interactions in coastal zones (Einsele 1992). The fluxes of continental water and sediment to a continental shelf largely depend on a region’s climate and local drainage-basin characteristics, which together affect the hydrology of contributing rivers (Jones and Frostick 2002; Burt and Allison 2010). There are certainly other local factors that impact sediment delivery, including the anthropic influence.

Sediment is an integral part of coastal system. The term “sediment” refers mainly to sand, silt, clay, gravel, and bioclastic material that are transported by waves and currents along or near the coast but also by wind, along desert or arid coastline or between beach and dune.

The sources of beach material are the landmasses bordering the sea and the rivers, supplying the coastal area with cohesive and non-cohesive materials. In order to fully understand the coastal morphology in a specific area, it is necessary to have some knowledge of the geology of the area and of the sediment supply from the rivers. Other more special factors may influence the characteristics of the coastal area, such as the local flora and fauna as in the cases of coral coastlines and mangrove coastal areas. However, coasts defined by biological systems will receive little attention here.

Figure 1 gathers the main elements of the sediment cycle seen on a short time scale on coastal areas. It is inspired by a concept of sediment budget which is an

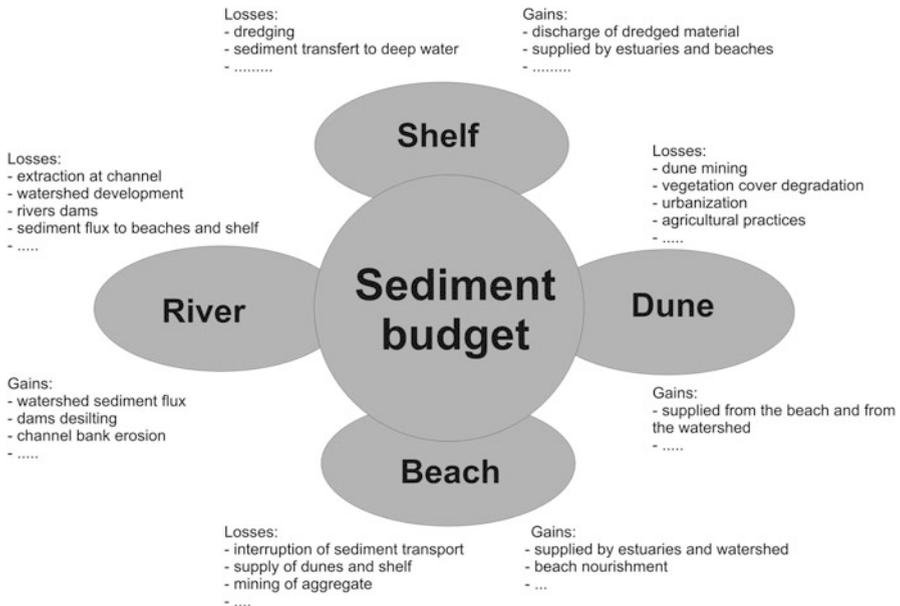


Fig. 1 Sediment budget principle on a coastal zone

accounting of the sources and disposition of sediment as it travels from its point of origin to its eventual outlet from a defined landscape unit like a drainage basin (Reid and Dunne 1996). We are concerned by sediment budget from land to see through four main coastal compartments which are trapping sediments over a given period or are providing sediments at other coastal compartments (shore, coastal dunes and cliffs, coastal hinterland watersheds and rivers, nearshore zone and beyond offshore zone forming a sink on a short period beyond the depth of closure – nevertheless the sediments of offshore compartments can be mobilized in case of severe climatic changes involving the decrease of sea level).

Sediment fluxes are driven by different factors, such as proximal (climate/glaciation, land cover, topography), distal (base level) and local controls (human activity). The principal influences on sediment flux during the Holocene are driven primarily by geography (temperature, runoff, biogeography and pedology), geomorphology (basin area and relief), geology (tectonic, lithology) and climate change (sea level change, flooding, storms, length of the season and El Niño events or Asian monsoon) (Jones and Frostick 2002).

Sediment fluxes to the ocean during the period from the late Jurassic to the Pliocene ranged between 2.7 and 5.2 Gt·year⁻¹, but increased up to 9.6–15.5 Gt·year⁻¹ in Pliocene-Holocene (Panin 2004). The contemporary sediment flux is 2, higher due to human disturbance of the coast and the land (Milliman and Syvitsky 1992). Over the Anthropocene which spreads over the last three centuries, however, large-scale human activities like dam, jetty and seawall construction challenge natural processes like changing sea level and major storms have influences on the shoreline position (Pilkey and Dixon 1996). Quick land cover changes over wide areas into watershed also impact water and sediment fluxes. From a quantitative point of view, the impact of watershed management by humans has first led to an increase in natural sediment supply to the ocean due to soil erosion (+2.3 +/-0.6 billion tonnes/year) and now leads to a decrease (1.4 +/-0.3) due to sediment trapping in dams (about 30 % of the sediment flux coming from inland) (Syvitski et al. 2005; Vorosmarty et al. 2003). At this decrease overlap subsidence processes in the majority of large muddy deltas (Syvistki et al. 2009) because of a large pumping water, oil and gas in coastal sedimentary layers. Finally, on an annual-decadal time scale, human activities, such as dredging, spoil disposals and beach replenishment, along with storm-generated waves, are probably the most important factors in shaping the coast (Hill et al. 2004). Quantitative assessment of the relative importance of these processes and prediction of future beach behaviour remain important problems for coastal geologists and engineers (Thieler et al. 2000).

Today, the coastal erosion which is felt in a generalized way is thus the result of a well-known convergence of the following factors: (a) climatic changes: increase of the marine level, modification of the modes weather-sailors (winds, swell); (b) reduction in the sedimentary contributions of the rivers because of the extractions of sands and gravels or the stopping, and the progressive unpacking, of the basins slopes; (c) reduction in sand stocks available on the spot because of urbanization; and (d) disturbances of the sedimentary transit by harbour works or protections which can defer the problem on the close sectors (Fig. 2). Hence coastal and marine sediments are limited in quantity and should be managed sustainably.

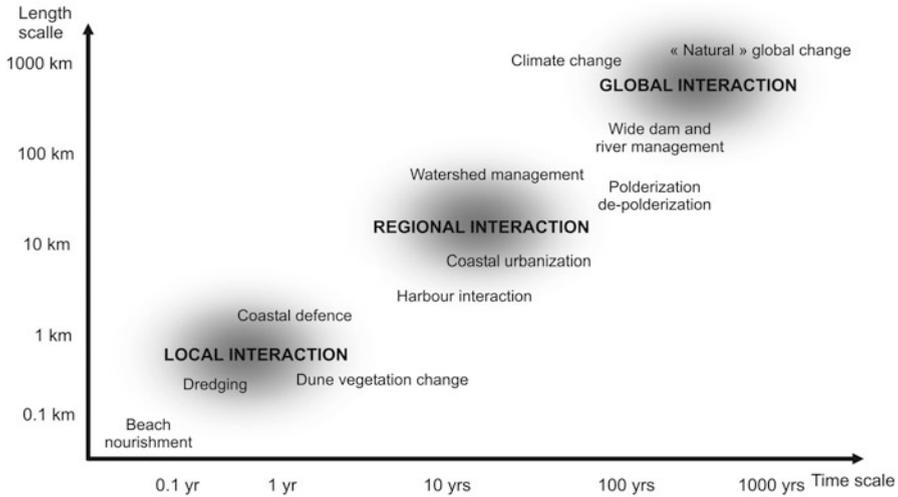


Fig. 2 Examples of human interaction with sediment fluxes in coastal area at various spatial and temporal scales

Moreover large amounts of sediment have been consumed on Earth for beach nourishment, land reclamation and construction.

Several studies gathering a wide and synthesized knowledge have been published concerning sedimentary fluxes at different spatial and temporal levels and different scientific issues. Jones and Frostick (2002) present a current perspective on controls and constraints on sediment supply, a model and empirically based driven understanding of sediment fluxes and the interaction of geomorphology, landscape evolution and sedimentary geology to provide a more complete picture of the Earth system. Crossland et al. (2007) addressed key elements of material flux between land, sea and atmosphere through the coastal zone and indications of: (i) change in land use, climate, sea level and human activities alter the fluxes in the coastal zone, and affect coastal quality and morphodynamic; and (ii) change in coastal systems, including responses to varying terrestrial and oceanic inputs, will affect the global carbon cycle and the trace gas composition of the atmosphere with an assessment of the influence of human society, before looking at future needs for targeted research and management actions in the coastal zone. More recently Burt and Allison (2010) published a volume entitled *Sediment Cascades: An Integrated Approach*. The aim of the book is to deal with sediment transport through the fluvial landscape with implications for catchment management, and consideration of larger-scale landform evolution. No single text integrates the landscape components we decided to include in the present book, covering the transfer of sediments from watershed environments, through transport pathways to the coastal zone under natural control (climatic and tectonic) at different time scales from the Holocene to the Anthropocene.

The book is a collection of many case studies carried out by researchers from several countries. These studies are provided by a large international spectrum of

researchers and presented in a uniform structure, focussing particularly on sediment fluxes in different coastal regions and at various spatial and temporal scales.

The aim of the first part is to show the impact of the climatic change on sediment fluxes over a long period (Holocene) through the study of three cases. The first case concerns drastic Holocene environmental change on the north-east Atlantic coast (Baltzer et al.), the second case concerns impact of deglaciation during Holocene upon sediment flux in a polar coastal zone (Strzelecki et al.). The last one is a case-study along the coast of Rhone Delta over a shorter period during the little ice age which ends at the beginning of Anthropocene period (Provansal et al.).

The aim of the second part is to focus on processes and resulting landforms over the Anthropocene period which is ongoing since the development of the industrial time. Three studies have been chosen in three different climatic areas: the first takes place in the tropical area of the French Guiana coast and is related to mud sediments (Anthony et al.). The second case studies a semi-arid country along the northwest coast of Morocco (El Mrini et al.). The last case takes place along the Channel Coast of France in Normandy characterized by high chalk cliffs, in a temperate climate (Costa et al.).

The third part of the book points out the use of modelling approaches of sediment fluxes at a higher spatial and temporal scale. In order to discuss the use of such modelling approach, we have chosen three cases: the first case addresses sediment exchange through the inlets of the Venice Lagoon in Italia (Umgiesser et al.). The second case highlights tidal inlet dynamics and relocation in response to artificial breaching on the west coast of Morocco (Zourarah et al.). The third case is focusing upon sediment transport formulae for coastal morphodynamic simulation, comparing calculated sediment flux against in situ data (Larroude et al.).

We propose a fourth part concerning extreme events such as tsunamis and associated sediment fluxes (Regnauld and Mastronuzzi). Tsunamis are not linked to climate changes nor to climate but must be taken into account because of their major and instantaneous impacts on sediment fluxes and sediment cells.

This book is an essential reading for academics, students and professionals belonging to a wide range of disciplines like geography, biology, modelling, environmental sciences, land planning and marine policy.

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