This section should be cited as follows: MacKay, F. and McKelvey, B. *Sand Mining.* in: Goble, B.J. and van der Elst, R.P. (eds.) 2022. State of the Coast: KwaZulu-Natal - A review of the state of KwaZulu-Natal's coastal zone. KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs, Pietermaritzburg, 179-184.

8.8 SAND MINING

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INTRODUCTION

By volume, the largest global extractive industry is mining of aggregates that constitute sand and gravel sediments (Peduzzi 2014). Sand mining is widespread, where every country mines or imports sand and the rate of sand mining far exceeds natural fluvial sediment supply with an ever-increasing deficit. The United Nations Environmental Programme describes this shortfall as "*one of the major sustainability challenges of the 21st century*" (UNEP 2019), where global aggregate consumption is estimated to increase from 40 to 50 billion tons per year in the next decade (Koehnken and Rintoul 2018). Sand supports the construction industry (aggregates in concrete), is used in industrial applications (industrial abrasives) (Chamber of Mines of South Africa 2017, Peduzzi 2014), for glass and electronics manufacture, and is targeted for land and beach reclamation (Torres *et al.* 2017).

At the coast, sand is mined from a variety of environments including riverbeds, estuaries, beaches, dunes or even the seafloor. Geological conditions and steep catchment gradients in KZN result in naturally high terrigenous sediment supply to rivers, estuaries and the downstream marine environment (Cooper *et al.* 1999). Although the practice is controlled in many developed nations, in KZN sand mining is focused on rivers and estuaries. These ecosystems are preferred for industrial applications due to the quality of the resource extracted. Fluvially-derived sands are well-sorted (mix of different sand sizes) by natural sediment transport processes and are of the market-preferred structure and composition (Kondolf 1994, Koehnken *et al.* 2020). The extraction of dune sands for heavy minerals is excluded from the local interpretation of sand mining, falling rather under dune mining (Section 8.7).

The industry is largely mechanised, typically using earth moving equipment in the channel and on river and estuary banks and floodplains, and using floating suction dredgers where water depth allows (Heath *et al.* 2004). These operations appropriate further land for large

Mining operation at the estuary interface, iLovu (2019)
Photo: Kierran Allen

equipment storage, vehicle maneuvering and resource stockpiles. They create their own access and haulage networks, collectively resulting in extensive habitat loss at mining sites.

Despite the plethora of knowledge and evidence related to the high environmental and socioeconomic costs of sand mining in these sensitive environments, the pressing need for development has consistently outweighed objective assessment of other benefits, and not recognised the longer-term effects to the greater socio-ecological system. A KZN-specific study showed that effects of sand mining correlate with estuary health and therefore the ability to provide other commercial, recreational and subsistence opportunities (in a healthy estuary). In short, the value of the resource is under-estimated, and the danger is that the resource becomes over-exploited (de Lange *et al.* 2008) against a background of a confused and poor regulatory system (Gondo *et al.* 2019). There has been a significant increase in illegal and uncontrolled activities in rivers and estuaries. Without deterrence and compliance enforcement, unauthorised and poorly managed operations have caused "*irreversible destruction*" to rivers and estuaries and presented diverse challenges related to legislation and the social and ecological environments (Chevalier 2014).

DRIVERS

Development and economic imperatives drive sand mining in KZN. As with elsewhere (e.g., Ahmed *et al.* 2020), the motivation for sand extraction is derived from economic and social development requirements, including infrastructure and housing. In KZN, this is connected to expanding coastal populations and an imperative to address multiple social issues through economic stimulus. The construction industry is the primary consumer of sand and gravel in South Africa, with reported sand mining revenue trending closely with construction revenue, and both have been increasing over the past decade (Mineral Council of South Africa 2010, 2019, PWC 2016). Of concern, in KZN the rapid increase in the sand mining footprint over the same period exceeded the national rate of increase in mined volume, suggesting a high increase in sand demand. It is anticipated that mining extent will continue to increase, given South Africa's need for continued economic development.

PRESSURES

The effects and scale of sand mining in South Africa (coastal KZN in particular) has elevated this activity to the level of a distinct pressure that highly influences the estuarine state (Van Niekerk *et al.* 2019). Nonetheless, there are specific sand mining pressures that originate from the activity itself. Examples are the expansion of illegal operations that limit bona fide future opportunities, the alteration of watercourses that limit sand delivery to the coast, and the removal of riparian vegetation that causes bank instability and erosion.

The regulation framework intensifies sand mining pressure through lack of monitoring and control systems. Permitting procedures are poor screenings for operators lacking environmental awareness or who do not have the technical know-how to operate in sensitive environments, exacerbated by inaccurate reporting on extraction volumes. This is a demand-driven activity and a future change to more sustainable construction materials will influence sand mining.

STATE

There is no active monitoring of sand mining in KZN. Without information on scale and intensity, there is limited opportunity to quantify the

impacts on the health status and ecosystem condition of rivers and estuaries. However, the correlation of presence of sand mining (even historical) with compromised estuarine health status is high (Van Niekerk *et al.* 2019).

Historic perspective

Past mining activities can only be ascertained by gross national figures published annually by the Minerals Council of South Africa (Mineral Council of South Africa 2019). Also, regulatory mechanisms have performed poorly and official records are left incomplete by unlawful mining and a lack of compliance with environmental regulations (Heath *et al.* 2004, Amponsah-Dacosta and Mathada 2017, Bendixen *et al.* 2019). In situ monitoring is impractical given that clandestine operations are often located in remote areas (Chaussard and Kerosky 2016, Duan *et al.* 2019) and that the industry is globally associated with violence and intimidation (UNEP 2019). Three historical sand mining studies have been done in KZN: Demetriades (2007) conducted an aerial survey of 64 KZN estuaries in 2007, which enumerated 18 affected systems; Bredin *et al.* (2019) conducted a situational assessment that revealed that the extent of riverine mining in the study catchment tripled between 2004 and 2019; and a study on sand mining and sediment yields conducted in the eThekwini Metropolitan area by de Lange *et al.* (2008), found unsustainable over-exploitation of eThekwini sand stocks at the expense of other estuarine ecosystem services. None of these studies reported on the ecosystem condition of the affected environments. Thus, there are no historical baseline conditions or reference points.

Current state

The 2018 National Biodiversity Assessment identified sand mining as an emerging pressure that has resulted in permanent habitat loss in 12% of South Africa's estuaries (the majority of which are in KZN) and is on a trajectory of increase (Van Niekerk *et al.* 2019). The report was based on a survey (ORI, unpublished data) of 68 KZN estuaries using satellite imagery between 2001 and 2018, that found that 54% of surveyed estuaries were subject to direct (72 sites in 19 estuaries with mining within, or partially within the Estuarine Functional Zone (EFZ)) or indirect (35 estuaries with upstream river mining within 10 km of the EFZ) sand mining activities. This doubled the number of estuaries known to be impacted (Demetriades 2007). Mining was associated with all the relatively large Predominantly Open or Large Fluvially Dominated estuaries (Figure 8.5).

However, 44% of the sites intersecting the EFZ and 65% of upstream sites affected the smaller temporarily closed estuaries (Figure 8.6), including 20 Large Temporarily Closed estuaries and nine Small Temporarily Closed estuaries (Figure 8.6).

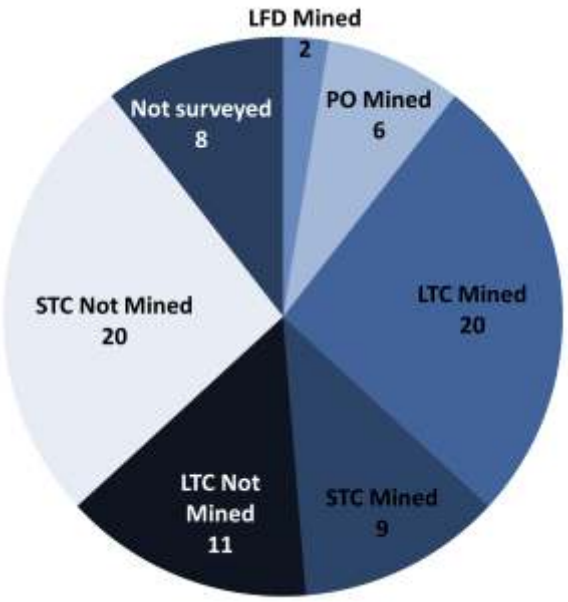

Figure 8.5: Distribution of sand mining sites by estuary type. LFD – Large Fluvially Dominated, PO – Predominantly Open, LTC – Large Temporarily Closed, STC – Small Temporarily Closed.

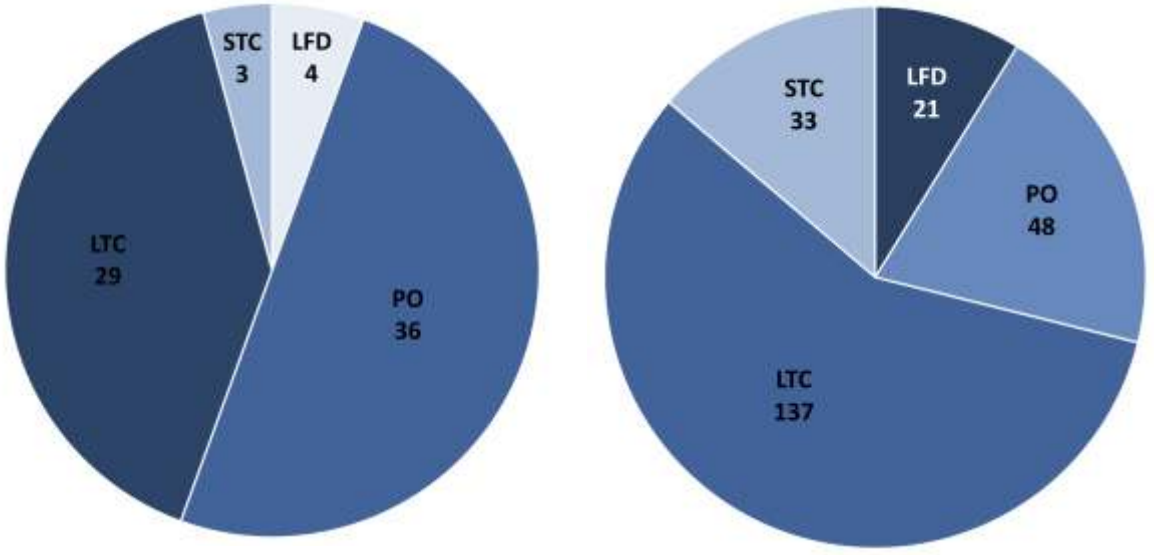

Figure 8.6: Number of mining sites intersecting the EFZ (left) and number of upstream sites within 10 km of the EFZ (right) grouped by estuary type. LFD – Large Fluvially Dominated, PO – Permanently Open, LTC – Large Temporarily Closed, STC – Small Temporarily Closed.

Local land-use strongly influenced mining pressure, regardless of estuary type. Considering the number and size of sand mining operations intersecting the EFZ, urban estuaries had the highest mining pressure (Figure 8.7), with large, permanent or semi-permanent mines, and a large number of upstream mining sites (within 10 km of the EFZ).

Smaller urban systems are typically in poor to very poor condition (Van Niekerk *et al.* 2019), and may lack the resilience or assimilative capacity to absorb sand mining impacts on estuarine function, resulting in disproportionate declines in estuarine health. Mostly untransformed estuaries in rural landscapes may have higher assimilative capacity, but more than half of these are identified as having high conservation value and impacts on estuary health would impinge on national conservation targets (Van Niekerk and Turpie 2012).

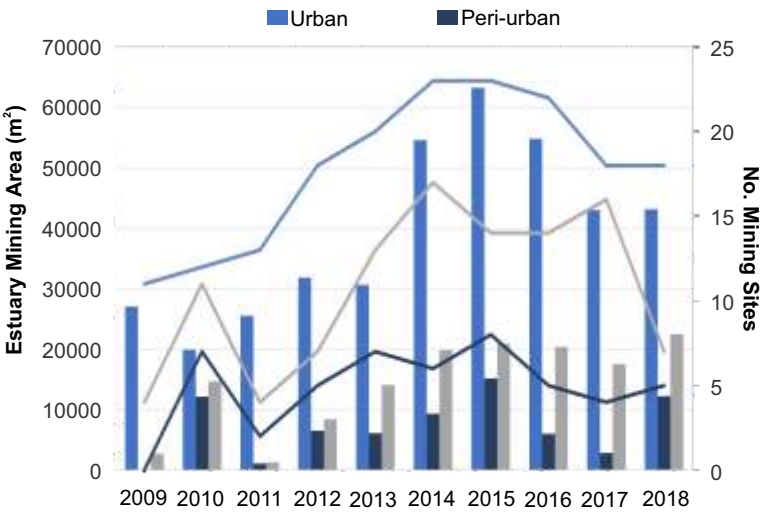

Figure 8.7: Sand mining footprint and number of mining sites intersecting the EFZ between 2001 and 2018, for 68 KZN estuaries.

IMPACT

There is a lack of quantitative data on the impacts of sand mining on rivers and estuaries in the global south (Koehnken and Rintoul 2018) and extrapolation from studies in the developed world can be problematic as effects can be context specific (Koehnken *et al.* 2020). However, universal effects are the loss of habitat complexity and biological diversity, with long-term impacts on rivers and estuaries (Le Bot *et al.* 2010, Latapie *et al.* 2014, Kędzior *et al.* 2016). Even operations that are

small and contained can cause habitat degradation, as riparian vegetation is removed and land is left unrestored and subject to alien plant invasion. Unsustainable mining rates in large urban estuaries have far-reaching consequences, as these are the drivers of sediment supply downstream to coastal and marine environments. The disruption of sediment transport exacerbates coastal erosion across the region (de Lange *et al*. 2008, Corbella and Stretch 2012) and limits the supply of sediment and nutrients to the marine environment.

Instream biota are affected; particularly non-motile burrowers and biological connectivity up- and downstream is interrupted, causing fish and crustacean migration blockages. This influences recruitment and even survival (Pitchaiah 2017), causing local extinctions and proliferation of invasive species (Freedman *et al.* 2013). Increased turbidity from instream dredging can influence biota health by limiting light penetration (reducing photosynthesis in plants) and reducing visibility for predators, clogging of gills, and even smothering of small invertebrates, thereby reducing overall food availability. Uncontrolled mining alters system morphology through bed degradation and changing longitudinal gradients and lowering bed elevations, widening channels and changing flow patterns (Leal Filho *et al.* 2021).

Various methods used to extract sand, including mechanical digging and dredging in an estuary (2019) ***Photo: Kierran Allen***

There are also economic and social impacts to sand mining. In KZN these have included human health risks (drowning in mined pits), limited access to natural habitats by local communities, damaged infrastructure (e.g., bridges and causeways), and reduced sand deposits. There are indirect impacts such as on tourism (shrinkage of bathing beaches), and although not noted in KZN, changes to recreational and subsistence fishing (Pitchaiah 2017).

It is anticipated that the extent and concomitant impact of sand mining on KZN estuaries will continue to increase given South Africa's need for economic development and the imperative to provide housing and essential services to under-served communities.

RESPONSE

KZN rivers and estuaries impacted by sand mining need urgent attention, starting with a critical need to address the governance gaps. The DMRE is responsible for the regulation of mining under the Mineral and Petroleum Resources Development Act. Since 2014, under the *One Environment System* the Minister of Mineral Resources and Energy is the competent authority for issuing environmental authorisation - a situation that is far from ideal whereby the Department is 'referee and player' (Chevallier

2014). Several key actions are needed to improve the sand mining impacts:

- Clarity on governance framework for mining, including which spheres are responsible for management, inspection and enforcement.
- In the recent KZN sand mining study, many operations were not authorised. Enforcement to shut down these activities is needed.
- Operators should submit and enforce environmental management plans.
- Whilst in operation, environmental best practice should be adopted. After mining, remediation of the site should be enforced (to date, no active restoration has taken place on KZN coastal rivers or estuaries).
- Consistent environmental monitoring is required. Prior to extraction, ecological baselines for the impacted environment should be ascertained and monitoring targets for restoration should be stipulated. The restoration levy should be commensurate to the ecological sensitivity and complexity of the environment mined.
- Detailed quantitative investigations are required on the biophysical effect of sand mining in the local context to inform impact assessment and region-specific strategic management planning and intervention, including cumulative impacts of multiple mines on a system over long time periods.
- Large estuaries with chronic mining should be prioritised for research and strategic intervention, as sediment delivery from these systems is the most critical to downstream marine and beach habitats. Smaller systems with high mining pressure, particularly those of high conservation value, should be closely monitored given the risk of long-term or permanent impacts on estuary health that impinge on national conservation targets.
- Increased public awareness is necessary around the dangers of illicit mining, the negative effects to the environment and the finite supply of sand as demand increases.
- Detailed mining inventories are required, including closed operations, to inform the scale of mining pressure on aquatic coastal systems and ecosystem recovery times.
- Alternate, sustainable materials for use in industry and construction should be investigated and promoted, including changes to building design.

Data Requirements

- The impacts of sand mining arise from habitat loss and sand deficits. Basic data on the location and extent of the mining footprint within coastal rivers and estuaries are required, including active mining pits, lay-down areas and the haulage road network.
- Sand mining is also a land-use concern. Remote sensing offers near real-time monitoring of mining extent into natural, transformed or developed land influencing other socioeconomic aspects. Using historical imagery, a retrospective analysis provides time series data as a reference point for future monitoring.
- In KZN, <10% of estuaries have had good bathymetry surveys for the last ten years. These are basic data that inform in-channel loss or transformation of subtidal habitats in the downstream receiving environment.
- Sand budget assessments are needed if not for every estuary, at least for regions of estuaries along the coast, focusing on estuary type. Data on the actual volumes of sand mined from estuaries (including illegal activities) are critical to the estimation of sand budgets and the identification of regional sand deficits.
- Updated hydraulic and hydrologic data are needed for coastal waterways to the ocean. Even basic information (flow, water levels) is not readily available for most systems.