

**The Sand Crisis: The Mining of Riverine and Floodplain Sand Within India**  
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## Context:

Sand is an under-appreciated but important resource. It is linked, directly or indirectly, to all 17 Sustainable Development Goals.<sup>1</sup> Seemingly abundant, sand is quickly becoming a scarce commodity as we are scooping, digging, mining, and dredging sand at an estimated rate twice that of natural replenishment.<sup>2</sup> Sand is used in concrete, asphalt, glass, fracking, land reclamation, and much more. We use so much that sand is second only to water as the most consumed natural resource.<sup>3</sup> We now require an average of 18kg of sand per person per day, that's a total of 50 billion tonnes globally each year.<sup>4</sup> Moreover, sand mining is one of the greatest contributors to the climate crisis through resulting carbon emissions of industries such as the concrete sector, as well as resulting damage to habitats, species and biodiversity.<sup>5</sup>

Urbanisation and subsequent construction is a main driver of sand mining. This is due to construction being geared towards sand-based materials. By 2050 it is expected that 68% of the world's population will live in urban areas.<sup>6</sup> In 2017, demand for sand worldwide was expected to double by 2060.<sup>7</sup>

Although the sand crisis is a worldwide issue, the focus of our research is India, where two of our team members are from. Namratha remembers seeing mining happening along the Periyar River about 10 years ago. When locals noticed the deepening of the river, strict police patrolling stopped the mining, at least to her knowledge. We narrowed our research to India in order to more fully explore the specific effects of sand mining. Sand mining, both legal and illegal, is prevalent in India. With Prime Minister Narendra Modi promising the equivalent of a new Chicago built yearly, India is in the midst of a construction boom.<sup>8</sup> Subsequently, the amount of construction sand used in India has increased. It was estimated in 2017 to be 700 million tonnes annually, increasing by 6-7% yearly,<sup>9</sup> and in 2019 had tripled since 2000.<sup>10</sup> We further narrowed our topic by focussing on the effects of riverine and floodplain sand mining, therefore excluding coastal and marine sand mining from our discussion.<sup>11</sup>

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<sup>1</sup> Sand and Sustainability: 10 strategic recommendations to avert a crisis., 2022

<sup>2</sup> Peduzzi, 2014

<sup>3</sup> Beiser, 2019

<sup>4</sup> Sand and Sustainability: Finding New Solutions for Environmental Governance of Global Sand Resources, 2019

<sup>5</sup>Recent research estimates that if the concrete industry was a country it would be the third biggest carbon polluter in the world, churning out almost three billion tons of harmful CO2 every year (Roach, 2022). Other research on the extraction of construction minerals, such as sand, indicates that sand mining is linked to destruction of threatened "red list" species of animals and plants and over 24,000 species overall (Torres et. al. 2022).

<sup>6</sup> Sand and Sustainability: 10 strategic recommendations to avert a crisis., 2022

<sup>7</sup> Buckiewicz, 2021

<sup>8</sup> ABC News In-depth, 2017

<sup>9</sup> Gupta, 2020; Government of India Ministry of Mines, 2018

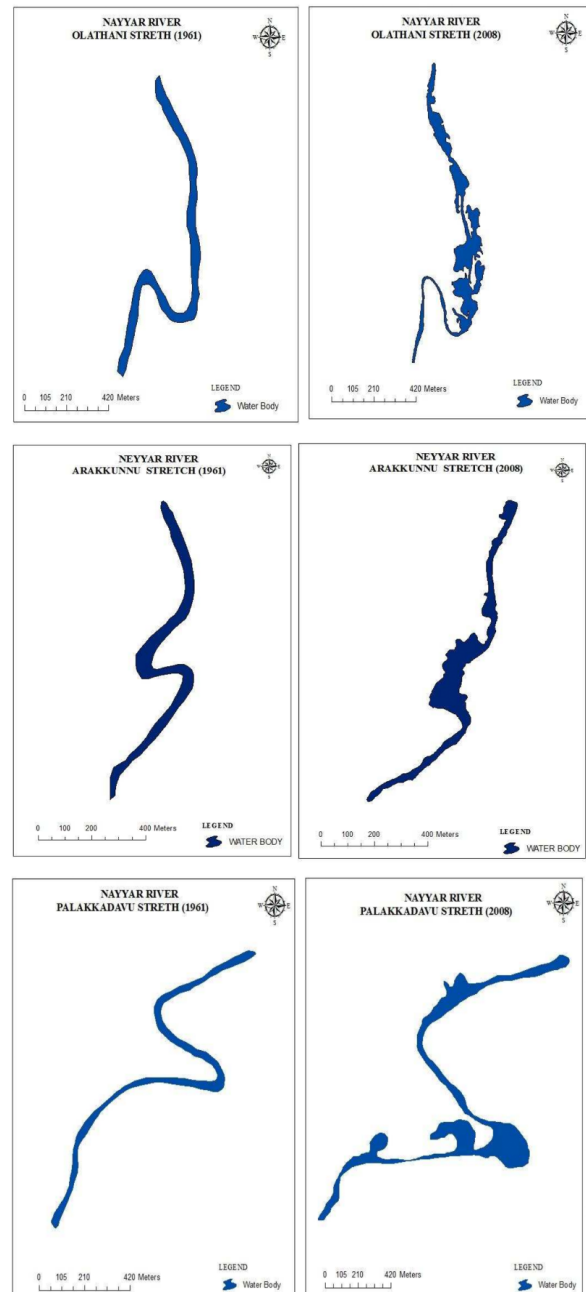
<sup>10</sup> Beiser, 2019

<sup>11</sup> River and floodplain mining are typically preferred as they tend to be closer to cities, reducing transport costs, of angular shape which is suited to construction (unlike desert sand), easily accessible and naturally sorted by grain size (Koehnken, 2018). River and floodplain sand is also preferred to marine sand due to marine sand requiring thorough washing to remove the salt (Peduzzi, 2014).

## Understanding the Challenge:

Sand is considered a **common-pool resource**.<sup>12</sup> Driven by increased urbanisation, associated construction – and unrestricted sand mining – we are headed towards a ‘tragedy of the commons’.<sup>13</sup>

The unnatural removal of sand from riverbanks, riverbeds and floodplains can alter rivers' courses.<sup>14</sup> Mining has caused the Neyyar River in southern India to change dramatically over nearly 50 years. Some stretches have almost doubled in width and others, more than tripled. Additionally, the river has been straightened for 112m where it wasn't previously. This widening and changing of the river's course means land is lost, with over 50 acres lost along one stretch of the Neyyar.<sup>15</sup> Furthermore, the remaining land is destabilised, threatening homes, livelihoods, and infrastructure.<sup>16</sup> An example is the Mahad bridge, spanning the Savitri River, which collapsed killing at least 28 people. This has been attributed to illegal sand mining weakening the bridge's foundations and altering the flow of the river.<sup>17</sup> In Uttar Pradesh, sand mining on the banks of the Ganges is eating into the sand beneath funerary ghats.<sup>18</sup> This leads to a reinforcing feedback loop where the loss of buildings and other infrastructure due to destabilized land means that more construction is needed, and more sand is mined, creating a vicious cycle that perpetuates the impact of India's sand crisis.



Illustrations of the changes in the course of the river Neyyar from 1961 to 2008 (Shaji & Anilkumar, 2014).

<sup>12</sup> A common-pool resource is one that is free for anyone to take, primarily due to the difficulty and cost of limiting access to it (Torres et al., 2017) The tricky nature of common-pool resource management is a hotly debated topic. Debates over scope of legislation, enforcement, whether management should be through private or public organizations, etc. are all issues which increase the difficulty of creating management systems, especially in countries with weak or divided states or where corruption is an issue. (Ostrom et al., 1994)

<sup>13</sup> ‘Tragedies of the commons’ describes an economic concept where everyone has access to a natural resource and consumes it without restriction until it leads to the complete depletion of that resource (Miller, 2021).

<sup>14</sup> Salopek, 2021

<sup>15</sup> Shaji & Anilkumar, 2014

<sup>16</sup> Umesh & Murthy, 2014

<sup>17</sup> Meynen, 2017

<sup>18</sup> Funerary ghats are riverside pyres where Hindus cremate their dead. (Salopek, 2021)

Rivers are also deepened due to the removal of riverbed sand. The bed of the Vembanad Lake catchment in India, for example, has been lowered by 7-15cm per year<sup>19</sup> and the Periyar River has been lowered by 19cm per year.<sup>20</sup> Lowering riverbeds can cause the water table to drop, and in some instances rivers to dry up.<sup>21</sup> 60% of wells in the area surrounding the Manimala River were affected by water shortage due to the lowering of the riverbed.<sup>22</sup> Water scarcity also affects the area's flora and fauna and has negative influences on livelihoods, as soil and wells grow drier, affecting the livelihoods of farmers and food supplies.<sup>23</sup>

The mining of riverine sand and especially the dredging of riverbeds causes immense ecological damage. Life-sustaining habitats and natural systems are destroyed and organisms are killed in the act of dredging.<sup>24</sup> Similarly, mining causes sand plumes which limits light to plant life, chokes fish – especially plankton – and triggers other damaging consequences to the natural environment.<sup>25</sup> This causes a loss of biodiversity within, and surrounding rivers which in turn threatens the livelihoods of people who rely on the rivers for income, such as fisherfolk.<sup>26</sup>

In another reinforcing feedback loop, the decline of fishing and farming livelihoods due to sand mining, often causes those who depend on these sectors to turn to sand mining themselves, as they are no longer able to make a decent living through fishing and farming alone.<sup>27</sup> This is common in India where new legislation allows farmers to extract up to 3-feet of earth from their fields without any environment clearance certificate.<sup>28</sup>

In India, illegal sand mining is especially common. Miners can make \$15 for a boat-full of sand, while the average daily wage is about \$4.<sup>29</sup> The shifts are also shorter because more money is earned, so mining often starts in the early morning but finishes by noon.<sup>30</sup> This attracts people to sand mining, the majority of whom will join informal and illegal mining groups as they make up the majority of sand miners in India. India alone generates a conservative estimate of \$250 million annually from illegal sand mining.<sup>31</sup> It is estimated that globally, of the approximate 40 billion tonnes of sand mined each year, less than half is traded legally.<sup>32</sup>

‘The Sand Mafia’ is what the media has named sand mining groups who are violent in nature.<sup>33</sup> ‘The Sand Mafia’ is known to receive political protection. Each state makes its own

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<sup>19</sup> Peduzzi, 2014

<sup>20</sup> Padmalal et al., 2007

<sup>21</sup> Peduzzi, 2014

<sup>22</sup> Sreebha & Padmalal, 2010

<sup>23</sup> Umesh & Murthy, 2014

<sup>24</sup> Beiser, 2019

<sup>25</sup> Prabhakar et al., 2019

<sup>26</sup> Sreebha & Padmalal, 2010; Mark, 2021

<sup>27</sup> Mark, 2021

<sup>28</sup> Many farmers are already engaged in illegal sand mining in India. The environmental impact of this new legislation, as well as the illegal activity, is not clear, but many environmental scientists estimate the damage will be irreparable (Agnihotri, 2022).

<sup>29</sup> Thomson Reuters Foundation, 2017

<sup>30</sup> Shaji & Anilkumar, 2014

<sup>31</sup> ABC News In-depth, 2017

<sup>32</sup> Mark, 2021

<sup>33</sup> Mark, 2021

policies on sand mining, so, state-level politicians and local authorities are taking bribes to look the other way.<sup>34</sup> People are forced by ‘The Sand Mafia’ to sell their land and are attacked if they do not comply.<sup>35</sup> Sonu Kumar Chaudhary, a police officer in Agra, was hit by a vehicle carrying sand while pursuing it, on the same day a journalist investigating illegal sand mining was hacked to death, both allegedly connected with ‘The Sand Mafia’.<sup>36</sup> This kind of violence leads local authorities to give in or avoid monitoring illegal mining.<sup>37</sup> Reports suggest that over 190 people were killed due to illegal sand mining within two years.<sup>38</sup> This is likely a conservative number as many deaths associated with illegal mining go unreported.<sup>39</sup>

**Death toll in India due to Illegal Sand Mining in 2019-20**

| Zone           | Drowning in sand pits | Mine collapse | Road accidents | Killing of Citizens/Villagers/Farmers | Killing of Reporters/Activists | Killing of Govt. officials | Killing in Gang-war/Encounter/Infighting | Total      |
|----------------|-----------------------|---------------|----------------|---------------------------------------|--------------------------------|----------------------------|--|------------|
| North          | 60                    | 3             | 18             | 6                                     | 1                              | 5                          | 2  | 95         |
| West & Central | 9                     | 20            | 4              | 3                                     | NA                             | 2                          | 4  | 42         |
| East           | 26                    | NA            | 4              | 4                                     | 3                              | 4                          | NA                                       | 41         |
| South          | NA                    | 4             | NA             | 5 (+5*)                               | 1                              | NA                         | NA                                       | 15         |
| <b>Total</b>   | <b>95</b>             | <b>27</b>     | <b>26</b>      | <b>23</b>                             | <b>5</b>                       | <b>11</b>                  | <b>6</b>                                 | <b>193</b> |

*5\* construction workers in Andhra Pradesh have committed suicides due to sand scarcity following mining ban by the state government.*

Death toll in India due to illegal sand mining in 2019-2020 (Singh Rawat, 2020).

‘Pit mining’ is the extraction of sand using high power suction pumps. There are two forms of pit mining, wet and dry.<sup>40</sup> Wet pit mining forms large water-filled pits that have led to 25 people drowning in the area surrounding the Neyyar River. The stagnant water also provides a breeding ground for malaria-transmitting mosquitoes, a problem in the area.<sup>41</sup>

Sand mining and use also contributes to CO<sub>2</sub> emissions. The trucks used for transporting sand not only contribute to air pollution but also to water pollution through oil spills.<sup>42</sup> Concrete production contributes significantly to global greenhouse gas emissions. The CDIAC estimates that in 2010 nearly 5% of the world's greenhouse gas emissions came from cement production.<sup>43</sup>

### **Solutions Landscape:**

<sup>34</sup> Rai et al., 2019

<sup>35</sup>Shaji & Anilkumar, 2014

<sup>36</sup> Gupta, 2020

<sup>37</sup> Rai et al., 2019

<sup>38</sup> Singh Rawat, 2020

<sup>39</sup> Thomson Reuters Foundation, 2017

<sup>40</sup> Prabhakar et al., 2019

<sup>41</sup> Shaji & Anilkumar, 2014

<sup>42</sup> Sreebha & Padmalal, 2010

<sup>43</sup> CDIAC stands for Carbon Dioxide Information Analysis Centre (Peduzzi, 2014).

Within India, legislation is the main form of solution efforts. Each state is responsible for creating its own policies, monitoring and measuring systems. Policies depend on the objective of the state, usually to maximise revenue or keep sand prices down. Furthermore, some states operate with a free market for sand, while in others the government controls the price.<sup>44</sup> These unaligned policies make it easier for illegal operations to run. To mine sand legally in India you must acquire a licence from the relevant State Government. In states such as Haryana and Uttar Pradesh, you can obtain a licence for mining but only for specific areas.<sup>45</sup> Breaking the rules is often easier than complying,<sup>46</sup> which goes to show that the policies are ineffective and poorly enforced. Between 2016 and 2019, over 45 thousand court cases were filed across India in relation to illegal sand mining.<sup>47</sup> Recently, Uttar Pradesh has banned mining altogether so that their rivers can regenerate sand.<sup>48</sup> In Mumbai, policies have changed so sand is cheaper to purchase and mining permits easier to gain, these changes are meant to reduce illegal mining but do not address the environmental impacts.<sup>49</sup>

The district of Rupnagar has a checkpoint to identify vehicles carrying suspicious cargo but this has led to only the drivers transporting the illegally mined sand being penalised and not the leaders of the organisations.<sup>50</sup> A toll-free number for people to file complaints about sand mining has also been implemented in Rupnagar.<sup>51</sup>

Aside from these efforts, there are some alternative materials being utilised within India. Due to a difference in the GST rate for building materials upcycling waste streams (5%-12%) and materials for concrete construction (18%-28%) some alternative materials have been developed: AgriBioPanelsTM, is comprised of over 90% straw and Agrocrete®, a carbon-negative material is made from crop residues and industrial by-products.<sup>52</sup>

Worldwide, scientists are finding new ways to compose concrete with less sand, or even without sand.<sup>53</sup> Some materials produced within India that can be used as a partial substitute for sand within concrete are copper slag<sup>54</sup>, bottom ash<sup>55</sup> and recycled demolition waste.<sup>56</sup> India produces 6-6.5 million tonnes of copper slag which can replace half of the sand in concrete while maintaining adequate quality. In 2014, India produced 15-20 million tonnes of bottom ash which can replace 30% of the sand in concrete and still have good strength. It is estimated that 1.5 million tonnes of demolition waste is generated within Delhi alone.<sup>57</sup> IIT Bombay estimates that by recycling the materials in dumps across India, enough aggregate

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<sup>44</sup> Government of India Ministry of Mines, 2018

<sup>45</sup> Umesh & Murthy, 2014

<sup>46</sup> Misra, 2022

<sup>47</sup> Rai et al., 2019

<sup>48</sup> Salopek, 2021

<sup>49</sup> Sand Set To Get Cheaper Under New Mining Policy | Mumbai News - Times of India, 2022

<sup>50</sup> Gupta, 2020; Misra, 2022

<sup>51</sup> Misra, 2022

<sup>52</sup> Sand and Sustainability: 10 strategic recommendations to avert a crisis., 2022

<sup>53</sup> Beiser, 2019

<sup>54</sup> Copper slag consists of the impurities extracted from copper when smelting, often discarded as a waste product. (Grit Sablare, 2018)

<sup>55</sup> Bottom ash is a waste product of combustion in power plants. (Umesh & Murthy, 2014)

<sup>56</sup> Umesh & Murthy, 2014

<sup>57</sup> Umesh & Murthy, 2014

could be produced to halt sand mining country-wide.<sup>58</sup> Concrete made from recycled demolition waste has roughly 10-15% less strength than regular concrete but is still usable in non-structural applications e.g., filling and flooring.<sup>59</sup>

The parties benefiting from the current system include legitimate sand mining companies, illegal mining groups, the Sand Mafias, the corrupt police and politicians who profit from the



Sand mining along Sone River in Bihar state (Salopek, 2021).

Sand Mafias, and the construction industry.

If the system were to change, the communities near sand mining sites would benefit as many of the detrimental effects would lessen, or begin to recover, however, many people are employed in the business of sand mining and professions like fishing and farming will not recover overnight. In Maharashtra state, the government promised to end illegal sand mining and provide jobs for those displaced, but almost a year later while there are significantly less sand mining boats present, the promised jobs have yet to appear.<sup>60</sup> These considerations not only have to be made but actually implemented if any long-term and wide-spread change is expected to happen.

It could be possible for legitimate sand mining companies to maintain profits through a system change. This is because globally it is estimated that only 15 billion of the 40 billion tonnes of sand mined annually are done so legally.<sup>61</sup> So, if sand usage was reduced but simultaneously regulation was improved, the illegal operations could incur the loss. There may be resistance to the extra admin that comes with increased regulation and transparency which is something to consider when attempting to implement such changes.

Illegal mining operations, such as the Sand Mafias, would be disadvantaged if the system were to improve regulation. The disbanding of these groups would lead to a large number of

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<sup>58</sup> TEDx Talks, 2020

<sup>59</sup> Umesh & Murthy, 2014

<sup>60</sup> Srivastava, 2018

<sup>61</sup> Mark, 2021

people needing employment, many of them with a criminal history.<sup>62</sup> This would be something to consider when implementing a system change so as to not cause unintended negative consequences in the communities most disadvantaged by sand mining.

It is likely that corrupt politicians and police who profit from illegal mining groups would oppose any increased regulation and/or continue letting the illegal groups mine.

The construction industry may oppose any move away from concrete and other sand-based materials as construction is currently set up for these materials. A move to sand-substituted concretes would also incur a cost in switching production techniques. In the long run, these materials may be cheaper as many of the sand-substitutes are waste materials that would otherwise be discarded.

Another aspect to consider is the global sand trade. It is not only the developing countries where mining occurs that will be affected by a system change, but also the wealthy countries that import sand. These countries don't incur an environmental impact but will be affected by a reduction in sand mining. There is also the income that developing countries generate from sand exports. These impacts will need to be considered within any future solutions efforts.

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<sup>62</sup> Shaji & Anilkumar, 2014



## Impact Gaps, Levers of Change and Intervention Opportunities:

There is little awareness of the sand crisis which means there is very little being done to improve the situation. Therefore, the very first step must be to educate people. Education and awareness leverages from our mental models, the deepest section of the iceberg model, namely our misconceptions about the abundance of sand and the disconnect between the effects of mining and the use of sand-based materials. Changing people's perception of sand and sand-based materials is important in the move towards reducing sand use. This would be relatively easy to implement and still highly effective. It would entail finding ways to spread awareness of which materials use sand, what substitutes there are, and the impacts of sand mining. For example, the United Nations Environment Programme (UNEP) recently released a report discussing their 10 recommendations on how to deal with the sand crisis, one of the main aims being to increase awareness.<sup>63</sup> Another example is the N.G.O. Awaaz which has been involved in the fight against sand mining in India for many years. They raise awareness through photos, videos, TED talks, posting news articles about sand mining on their website, etc.<sup>64</sup> This could easily be scaled up to reach more people and is a good framework for other countries to spread awareness of their specific battle with sand mining.

While recycled aggregate and sand-substitute materials, such as Agrocrete® and AgriBioPanels™, are being used,<sup>65</sup> they are not used widely enough to create real change. This lever requires improved awareness to be widely implemented.



(Abdulali, 2021)

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<sup>63</sup> Sand and Sustainability: 10 strategic recommendations to avert a crisis., 2022

<sup>64</sup> About, 2006

<sup>65</sup> Sand and Sustainability: 10 strategic recommendations to avert a crisis., 2022

Continued research into this challenge is important so a deeper understanding can be reached. There is a distinct lack of information regarding the impacts of specific mining types eg, manual, wet or dry pit mining, bar skimming etc. Data is also lacking on volumes of sand extracted and replenished over time.<sup>66</sup> The UNEP includes ‘map, monitor and report sand resources’ in their recommendations and suggests actions such as investing in strategic resource mapping to allow us to better understand the scope of the problem. While research is already happening, it needs to continue and increase. This lever is possibly the most important as it will improve any efforts towards solving this challenge.

Increased regulation is needed but often forgotten is the lack of resources for monitoring and enforcement of new laws and policies.<sup>67</sup> The wide-spread nature of sand, as a common-pool resource, makes it resource intensive to regulate.<sup>68</sup> A global entity to oversee regulation and enforcement within the sand industry could help with this lack of resources. For example, the UNEP or the World Trade Organisation could set up a global program to do this. This could much improve the situation as many of the countries where excessive and illegal sand mining is prevalent, such as India, are developing countries without the resources to enforce laws passed against mining.<sup>69</sup> This may be the most impactful action to aid developing countries, but also the most difficult to implement and probably unrealistic in the current landscape.

Communication between stakeholders is extremely important within this system. Currently, there is little to no transparency as much of the sand traded is undocumented, meaning we don’t know where it was mined or if it was mined legally.<sup>70</sup> This is a shallower lever from the ‘system structures’ section of the iceberg, adding and strengthening relationships between key actors within the system. Increased communication between stakeholders such as industry, governments, miners and affected communities<sup>71</sup> could help reduce the prevalence of illegal mining without the need for a global entity, although they would be helpful in facilitating this communication. This would improve awareness of the impacts sand mining has at ground-level and possibly help facilitate a shift away from excessive and unregulated sand mining.

All of these leverage points will take time to plan and implement. There may be some more direct actions to be taken at the events level to subdue the impacts of excessive sand mining and help the affected communities while these bigger levers are worked towards. The UNEP includes ‘restore ecosystems and compensate for remaining losses’ as one of their recommendations suggesting actions such as preventing impacts, minimising unavoidable impacts, restoring ecosystem function post-impact, and offsetting the remaining impacts<sup>72</sup>.

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<sup>66</sup> Mark, 2021

<sup>67</sup> Mark, 2021

<sup>68</sup> Buckiewicz, 2021

<sup>69</sup> Mark, 2021

<sup>70</sup> Mark, 2021

<sup>71</sup> Meredith, 2021

<sup>72</sup> Sand and Sustainability: 10 strategic recommendations to avert a crisis., 2022

## **Lessons Learned:**

Through our research, we learnt that the sand crisis is a much bigger problem than we had realised. It became clear that the current solutions landscape is not well suited to the countries where sand mining is most prevalent, especially India. The problem engages with much larger complex problems such as global urbanisation, and yet effects at local levels include many detrimental social and environmental problems. Solutions aiming to improve the social impacts often exacerbate the environmental impacts. The two sides of the problem, environmental and social, interact in complex ways making the challenge impossible to improve without a systems perspective.

To make sustainable change within this system the problem must be looked at from many perspectives. Global and local, corporations and communities, all viewpoints must be addressed to enact real, lasting change.