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Repository Citation

Emily Tastet, *Stealing Beaches: A Law and Economics Policy Analysis of Sand Mining*, 7 LSU J. of Energy L. & Resources (2019)
Available at: <https://digitalcommons.law.lsu.edu/jelr/vol7/iss2/11>

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INTRODUCTION

Before she earned the nickname of “minister of noise” for her activism against noise pollution in Mumbai, Sumaira Abdulali fought a much more sinister adversary in India: the sand mafia.¹ One night, Abdulali heard the sound of trucks on the beach by her house. She notified the police that men were stealing sand from the beach. The police warned her to stay away because the men were illegal sand miners.² Abdulali did not heed this warning and confronted the miners, who attacked and beat her.³ Afterward, Abdulali filed a lawsuit against the men who attacked her, which resulted in the Bombay High Court banning sand mining, at first in vulnerable areas, then later in the entire state of Maharashtra.⁴

Sand is one of the main aggregates in the construction process, and companies use it in the production of countless goods.⁵ Sand is a very important resource, especially to countries that are developing infrastructure and experiencing mass urbanization through a rapidly expanding middle class.⁶ As mass urbanization grows, so will the demand for sand.

Different countries value and use sand unequally, which creates various issues.⁷ Scientifically, sand is a renewable resource; however, the world consumes sand at a faster rate than the resource renews itself.⁸ This causes a shortage of sand, which is not sustainable in any construction-dependent economy. The environmental consequences of depleting sand through mining outweigh the benefits of construction. Yet there are available substitutes. This issue leads to the question of whether governments should regulate sand at all; and, if so, how much? The current lack of a comprehensive regulatory policy and the growing black-market lead to

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1. Nick Meynen, *Is Sand the New Oil? The Global Battle for Sand is Getting Ugly*, ENVTL. JUST. (May 15, 2017), <https://perma.cc/R8TJ-LB7V>.

2. *Id.*

3. *Id.*

4. *Id.*

5. Pascal Peduzzi, *Sand, Rarer Than One Thinks*, UNITED NATIONS ENV'T. PROGRAMME (UNRP) (March 2014), <https://perma.cc/FAQ3-FUMQ>.

6. *An Improbable Global Shortage: Sand*, ECONOMIST (Mar. 30, 2017), <https://perma.cc/E23P-7HQ2>.

7. Peduzzi, *supra* note 5.

8. *Id.*

indiscriminate mining, which creates major environmental, ecosystem, and economic concerns.⁹

Different forms of government intervention, such as taxation or regulation, cure market failure.¹⁰ To avoid government failure, legislatures must be careful when contemplating a regulatory or taxing scheme. An ideal solution to avoid both market and government failure is a regulatory scheme that does not outlaw sand mining completely but balances both the misallocation of resources in the market as well as incentives for developers and miners who obey the law.

In addition to a regulatory scheme, a recyclable material use program would alleviate the constant demand for sand. Through such a program, construction companies could recycle concrete in demolished buildings or use crushed glass or fly ash as aggregates instead of sand.¹¹ Sand mining does not have to stop completely, but the rate in which sand mining occurs needs more oversight.

Part I of this Comment addresses common uses for sand, the mining process, and the sand shortage. Part II explores the environmental impact of sand mining on a global level. Part III addresses the economic concerns of sand mining and market failure. Finally, Part IV proposes three viable solutions to combat sand shortage and discusses alternative materials to replace sand. The world has an interest in protecting this resource. As an international issue affecting countries all over the world with different political regimes, economies, and views about solving the problem, finding a single solution to apply to every country is not plausible.¹² This Comment proposes multiple regulatory solutions remedying the misallocation of sand in the market in order to fit the different needs of various countries and their governments.

I. BACKGROUND

Companies use sand not only in creating concrete and asphalt but as a base under these materials when building roads, buildings, and other structures.¹³ Each ton of concrete requires approximately six to seven tons

9. *Id.*

10. JONATHAN GRUBER, PUBLIC FINANCE AND PUBLIC POLICY 3 (5th ed. 2015).

11. Peduzzi, *supra* note 5, at 9.

12. See Michael Ilg, *Environmental Harm and Dilemmas of Self-Interest: Does International Law Exhibit Collective Learning?*, 18 TUL. ENVTL. L.J. 59 (2004).

13. David Owen, *The World is Running Out of Sand*, NEW YORKER (May 29, 2017), <https://perma.cc/V9DC-AUTW>.

of sand and gravel.¹⁴ Additionally, sand is used to make glass and microchips and to expand land mass to combat coastal erosion.¹⁵

Sand is vital to certain industries, particularly the construction industry; but the increased mining of this aggregate has major environmental consequences. Over-extracting sand mainly occurs in underdeveloped or developing countries, where governments lack the authority or capacity to establish and enforce regulations. This lack of enforcement capacity and political accountability allows for illegal sand mining, which only exacerbates environmental and economic problems.¹⁶

A. How Sand is Made and Mined

Over time, weathered particles of rock create natural sand.¹⁷ Rivers carry sand and deposit it around the world. Some of the grains end up in riverbeds or along the banks of rivers, and others accumulate by the sea.¹⁸ There are many different types of sand, including river, marine, and desert sand. River sand and gravel are more commercially profitable to mine than other types of sand.¹⁹ Desert sand is not suitable for construction or land reclamation because wind erosion makes the grains perfectly round and thus unable to adhere together.²⁰ At first, sand was primarily mined from riverbeds and land quarries. Due to increasing demand, strict environmental regulations, and some countries banning this practice, the demand for marine sand has escalated.²¹ Miners extract sand from the river manually or mechanically, using high-power jet pumps.²² Mining marine sand is gaining popularity; however, this process is more expensive than mining river sand because in order to use the marine sand for concrete, it must first undergo a washing process to remove any salt particles.²³ River and marine sand are the main aggregates used for building and land reclamation. River and in-

14. Marius Dan Gavriletea, *Environmental Impact of Sand Exploitation. Analysis of Sand Market*, MDPI: SUSTAINABILITY 3 (June 26, 2017), <https://perma.cc/TZ66-A5BD>.

15. *Id.* at 2.

16. *Id.* at 3.

17. D. PADMALAL & K. MAYA, SAND MINING ENVIRONMENTAL IMPACTS AND SELECTED CASE STUDIES 5 (Springer 2014), <https://link.springer.com/content/pdf/10.1007%2F978-94-017-9144-1.pdf>.

18. Vince Beiser, *The Deadly Global War for Sand*, WIRED (Mar. 26, 2015), <https://perma.cc/X3L5-BBP6>.

19. PADMALAL & MAYA, *supra* note 17, at 24.

20. Peduzzi, *supra* note 5, at 3.

21. Gavriletea, *supra* note 14.

22. PADMALAL & MAYA, *supra* note 17.

23. Peduzzi, *supra* note 5, at 3.

stream gravel are the best aggregates for concrete because they require less processing. The best construction sand is found in riverbeds and land quarries.

B. The Sand Market

In 2016, the sand export market totaled around \$1.08 billion.²⁴ The import market totaled around \$1.5 billion.²⁵ The largest exporters of sand are the United States, the Netherlands, and Germany.²⁶ The largest importers of sand are Singapore, Canada, and Belgium.²⁷ These figures, however, do not account for the black-market value for sand.

C. The Problem with Sand Mining

As developing nations continue to grow, the need for construction and infrastructure increases. While sand is a renewable resource, the use of sand varies dramatically by type. The best type of sand for construction is river sand, however, changing river paths and damming rivers prevent sand from traveling to waterways and being distributed naturally.²⁸ A major problem with sand mining in river beds is that the sand currently depleting in riverbeds and on beaches will not be naturally replenished in those areas.²⁹

1. Impending Sand Shortage

Sand is an abundant resource, but mining practices lead to a shorter supply of sand in certain areas. Due to high transportation costs, specific areas may use exponentially more sand than others depending on where particular construction is located.³⁰ The lack of proper scientific methodology for river sand mining results in indiscriminate mining, weak

24. *Sand*, OBSERVATORY OF ECONOMIC COMPLEXITY, <https://perma.cc/F58C-27EK>.

25. *Id.*

26. *Id.*

27. *Id.*

28. PADMALAL & MAYA, *supra* note 17, at 5.

29. Bruce Edwards, *The Insatiable Demand for Sand*, THE INTERNATIONAL MONETARY FUND: FINANCE AND DEVELOPMENT (Dec. 2015), <https://perma.cc/KK55-39U3>.

30. Sonia Paul, *How India's Sand Mafia Pillages Land, Terrorizes People, and Gets Away With It*, VICE NEWS (October 7, 2016), <https://perma.cc/SU2S-3RWA>.

governance, and the prevalence of the sand mafia.³¹ These factors create a short supply of sand in certain areas. If countries continue mining indiscriminately without taking the proper precautions, then the shortage, and the sand mafia's exploitation of it, will only worsen.³²

2. *The Sand Mafia*

In an effort to combat the negative environmental effects of sand mining, many governments created permits systems to manage the quantity and location of sand mining. Some governments even completely banned sand mining in certain areas.³³ While these government actions effectively limited the access to the supply of sand, they did nothing to decrease demand. The escalating demand led to the proliferation of the sand mafia. The sand mafia is a group of people who profit from illegal sand mining by bribing police and government officials to continue their illegal mining practices.³⁴ It is even rumored that some members of the sand mafia infiltrate local governments in order to ensure the continuance of their operations.³⁵

India has the largest problem with the sand mafia. The sand mafia fuels the black market demand for sand by illegally mining to meet the increasing need for sand.³⁶ In the past few years, the sand mafia allegedly killed hundreds of people and targeted police officers, government officials, and whistleblowers attempting to stop illegal sand mining.³⁷ The sand mafia generates approximately sixteen to seventeen million dollars a week in illegal revenue.³⁸ Since the sand mafia operates outside of the law, it can illegally mine and supply sand more quickly than miners who abide by governmental regulations.

3. *Market and Government Failure*

Market failure exists when an inefficient allocation of resources occurs in the market.³⁹ There are four different types of market failures:

31. Peduzzi, *supra* note 5, at 7.

32. PADMALAL & MAYA, *supra* note 17.

33. See PADMALAL & MAYA, *supra* note 17, at 57.

34. Rollo Romig, *How to Steal A River*, N.Y. TIMES MAG. (Mar. 1, 2017), <https://perma.cc/XBA7-4XSQ>.

35. Beiser, *supra* note 18.

36. *Id.*

37. *Id.*

38. Paul, *supra* note 30.

39. GRUBER, *supra* note 10, at 3.

(1) externalities, (2) public goods, (3) imperfect information, and (4) market control (monopolies).⁴⁰ Environmental damage is an indicator of market failure due to the inefficient use of natural goods or resources.⁴¹ Another common indication of market failure is a shortage. The sand market is experiencing a market failure because the free market is not allocating the resource efficiently. There is a shortage of sand, and communities are experiencing negative externalities related to sand mining activity around their rivers. The types of market failure that affect the sand market are externalities and common-pool resources.

Typically, government intervention cures market failure.⁴² However, market failure is not the only problem with the sand market. The sand market also experiences government failure. Government failure occurs when a government intervenes in the market to cure a market failure; but, instead of solving the problem, it exacerbates it through inefficiency and a misallocation of resources.⁴³

D. Global Examples

Internationally, countries use sand differently based on the country's infrastructural needs. For example, as India's population grows, so does its demand for sand (it also had the worst illegal sand mining market).⁴⁴ China used more cement between 2011 and 2013 than the United States used in the entire twentieth century.⁴⁵ Singapore, the largest sand importer in the world, uses sand to expand its territory, adding around fifty square miles in the past forty years.⁴⁶ Singapore does not mine sand from its own country, but rather imports it from neighboring countries including Indonesia, Malaysia, Cambodia, and Vietnam.⁴⁷ After the Tsunami in 2004, mining sites increased around river basins in Sri Lanka.⁴⁸

40. ROBERT COOTER & THOMAS ULEN, LAW & ECONOMICS, 40–43 (3rd ed. 2000).

41. Mollie Lee, Note, *Environmental Economics: A Market Failure Approach to the Commerce Clause*, 116 YALE L.J. 456, 478 (2006).

42. COOTER & ULEN, *supra* note 40, at 40.

43. Government Failure, ECONOMICS ONLINE, <https://perma.cc/H5SM-M3BU> (last visited Oct. 2, 2018).

44. See PADMALAL & MAYA, *supra* note 17, at 68.

45. Gavriletea, *supra* note 14.

46. Gavriletea, *supra* note 14; Beiser, *supra* note 18.

47. *Id.*

48. L.H.P. GUNARATNE, POLICY OPTIONS FOR SUSTAINABLE RIVER SAND MINING IN SRI LANKA, *reprinted in* COST-BENEFIT STUDIES OF NATURAL RESOURCE MANAGEMENT IN SOUTHEAST ASIA 201, 202 (David James & Herminia A. Francisco eds., 2015).

Domestically, the United States mainly uses sand to extend shorelines which are eroding because of rising sea levels and other environmental factors.⁴⁹ The United States also uses sand in the hydraulic fracturing (fracking) process.⁵⁰

II. ENVIRONMENTAL IMPACTS OF SAND MINING

As an open resource that is relatively inexpensive to extract, calculating the amount of sand mined globally creates an absence of data, which makes it difficult to properly assess sand mining's impact on the environment.⁵¹ One way to circumvent the lack of available data is to look at the production of cement for concrete since sand and gravel are used as aggregates in this process.⁵² The United Nations makes a conservative estimate that the world's consumption of sand exceeds forty billion tons a year.⁵³

The most harmful environmental effects of sand consumption come from river sand mining.⁵⁴ As previously discussed, the rate of mining sand and gravel is higher than the replenishment rate, which could lead to adverse effects to rivers.⁵⁵ Specific data on the exact effects of river sand mining are hard to obtain and are usually specific to each mining site. There are multiple factors to consider when assessing damage to a river including: the type of sand, the scale of the extraction, the resistance of the river channel to erosion, the land use, and the sediment transport process, among other factors.⁵⁶

Although withering particles of rock normally replenish the supply of sand naturally, damming rivers and sand mining reduce sediment traveling from rivers to coastal areas, contributing to beach erosion.⁵⁷ Because transportation costs are the primary expense of sand mining, sand is typically mined in relatively close proximity to the market.⁵⁸ The precise negative environmental impacts of sand mining depend on whether sand is extracted from riverbeds or offshore sites and the geographical location of the site. Not only are there economic incentives to regulate sand mining,

49. Owen, *supra* note 13.

50. Renuka Rayasam, *Even Desert City Dubai Import its Sand, This is Why*, BBC (May 5, 2016), <https://perma.cc/9X6G-Q8A4>.

51. Peduzzi, *supra* note 5, at 1.

52. *Id.*

53. *Id.* at 2.

54. *See id.*

55. *Id.* at 31.

56. *See id.*

57. Peduzzi, *supra* note 5, at 5.

58. PADMALAL & MAYA, *supra* note 17, at 58.

but there are environmental motivations as well. While it is hard to say what exactly sand mining is doing on a global scale, it is clear from site-specific data that it is not good.⁵⁹ In order to continue growing and developing infrastructure, nations need to mitigate the environmental effects of sand mining and focus on sustainability.

A. River Sand Mining

River sand is mined more frequently than beach and marine sand because it is cheaper to mine.⁶⁰ Since transporting sand is expensive, sand miners often prefer mining in a river close to the construction site to lower costs.⁶¹ Mining river sand is ideal because it is the cheapest solution; however, the environmental effects to rivers are significant. Environmental impacts are specific to each mining site depending on numerous factors such as: location of the sand mine, size of the mining area, time of exploitation, secondary mineralogy, habitats and vegetation in the mining area, and method of exploitation.⁶² Rivers can experience river channel problems, surface water problems, ground water problems, and issues with local flora and fauna.⁶³ River channel problems include erosion of riverbanks, changes in the riverbed configuration, and lowering of riverbeds, as well as foundational structure damage to infrastructure such as bridges.⁶⁴ Surface water issues include salt water integration.⁶⁵ River sand mining also lowers groundwater tables and damages freshwater aquifer systems.⁶⁶

The effects of river sand mining stretch across the globe. In the Vembanad Lake in India, the riverbed lowers approximately seven to fifteen centimeters a year due to the removal of more than twelve million tons of sand.⁶⁷ Lake Poyang is the largest source of sand in China, producing around 236 million cubic meters of sand per year.⁶⁸ The exponential rise in sand mining resulted in the deepening and widening of the lake, increased water discharge into the Yangtze River, and potentially

59. See PADMALAL & MAYA, *supra* note 17, at 57.

60. Peduzzi, *supra* note 5, at 3.

61. PADMALAL & MAYA, *supra* note 17, at 67.

62. Gavriletea, *supra* note 14, at 14.

63. PADMALAL & MAYA, *supra* note 17, at 74.

64. *Id.*

65. *Id.*

66. *Id.*

67. Peduzzi, *supra* note 5, at 5.

68. For comparison, the UNEP states that sand extraction sites in the United States combine produce around 16 million cubic meters a year. Peduzzi, *supra* note 5, at 5.

lowered the lake's water levels.⁶⁹ In San Diego, the San Luis Rey River experienced significant erosion due to sand mining, which undermined infrastructure and aqueducts and caused a large loss of vegetation and animal habitats in the river.⁷⁰

River sand mining hurts the wildlife living in the rivers as well.⁷¹ The local ecology experience problems with river sand mining, such as reduced fish resources, insect population,⁷² and diversity in wildlife, as well as other effects caused by physical disturbance to the habitat.⁷³

Two examples of local ecology threatened by river sand mining are the gharial and the Ganges river dolphin. The gharial is an endangered crocodile in Asian rivers.⁷⁴ This crocodile's existence is threatened as river sand mining increases, stripping the banks of the rivers where these crocodiles bask.⁷⁵ The Ganges river dolphin is on the verge of extinction, threatened by river sand mining in India.⁷⁶ The catastrophic environmental effects that plague river systems because of sand mining also threaten the world's beaches.

B. Beach and Marine Sand

Lack of replenishment of sand to coastal beaches leads to coastal erosion and an increased risk of flooding to surrounding areas.⁷⁷ The impact of beach sand mining is not as detrimental to the environment as the negative impact of river sand mining.⁷⁸ There is a push to transition from river sand mining to offshore sand mining; however, this process is more expensive and requires machinery, unlike river sand mining (which individuals can do manually).⁷⁹ Beach sand mining causes beach erosion, loss of biodiversity, and a lack of flood protection to coastal communities.

69. *Id.* at 5.

70. Harold Magistrale, Comment, *Sand Mining in Baja and Alta California*, 6 SAN DIEGO INT'L L.J., 435, 439.

71. Aurora Torres, Jianguo Liu, Jodi Brandt & Kristen Lear, *The World is Running Out of Sand*, BUSINESS INSIDER (Sept. 11, 2017), <https://perma.cc/S5V2-DFJG>.

72. This applies to insects, like dragon flies, who lay their eggs in shallow water.

73. Gavriletea, *supra* note 14, at 15.

74. Torres, et al., *supra* note 71.

75. *Id.*

76. Aurora Torres, Jodi Brandt, Kristen Lear, & Jianguo Liu, *A Looming Tragedy of the Sand Commons*, 357 SCIENCE NO. 6355, Sept. 8, 2017, at 970.

77. Torres, et al., *supra* note 71.

78. PADMALAL & MAYA, *supra* note 17.

79. *Id.*

For example, onshore beach sand mining in Monterey Bay, California, causes long term beach erosion at a rate of about three to six feet a year.⁸⁰ While Singapore itself has not suffered negative environmental consequences from expanding its coast through land restoration, this is not the case for their neighboring countries that supply Singapore their sand.⁸¹ The environmental damage was so severe that Indonesia, Malaysia, Vietnam, and Cambodia have either banned or limited exports of sand.⁸² Indonesia has lost around two dozen islands since 2005 from supplying Singapore with the sand needed for expanding Singapore's coast.⁸³ Vietnam projects the country will run out of construction grade sand by the year 2020.⁸⁴

Before comprehensive legislation can effectively regulate sand mining, governments need to invest in extensive studies to determine the environmental impact of sand mining in particular areas. Most of the countries where sand mining is prevalent do not assess the environmental impact of sand mining.⁸⁵ One of the biggest problems is the lack of available information about the continued sustainability of the supply of sand.⁸⁶

III. ECONOMIC ANALYSIS OF SAND MINING

Economic analysis contributes to legal analysis on a normative level, by clarifying efficiency and value conflict and, on a positive level, by explaining how policy and legal decisions lead to certain outcomes.⁸⁷ Typically, three main types of market failure occur in an environmental context: externalities, public goods, and the tragedy of the commons.⁸⁸ Damage to the environment can be a consequence of inefficient use of goods in the environment, due to market failure.⁸⁹ The shortage of construction grade sand is an issue of externalities and common-pool

80. Peduzzi, *supra* note 5.

81. Beiser, *supra* note 18.

82. *Id.*

83. *Id.*

84. *Vietnam Forecasts to Run out of Construction Sand by 2020*, TUOI TRE NEWS (Aug. 3, 2017), <https://perma.cc/42X6-GHVL>.

85. PADMALAL & MAYA, *supra* note 17, at 48.

86. Peduzzi, *supra* note 5.

87. Russell S. Jutlah, *Economic Theory and the Environment*, 12 VILL. ENVTL. L.J. 1, 1–2 (2001).

88. Lee, *supra* note 41, at 478.

89. *Id.*

resources. Because the shortage of sand is a form of market failure, economic analysis can and should apply within an environmental context.

Market failure occurs when there is an inefficient allocation of resources in a free market.⁹⁰ Market failure implies that the price of sand does not reflect the social cost imposed on communities who are affected by sand mining practices.⁹¹ To fix a market failure, there is usually some sort of government intervention.⁹²

A. Externalities

An externality is a cost or consequence of economic activity that third parties who are not directly related to the production or consumption of that good experience.⁹³ In an environmental context, externalities occur when the market price does not accurately reflect the resource's scarcity.⁹⁴

Externalities can be either positive or negative.⁹⁵ The main positive externalities for sand mining are job creation in rural communities and improvements to infrastructure.⁹⁶ The rise of river sand mining in Sri Lanka created jobs for the rural population, including miners, transporters, and vendors.⁹⁷ Negative externalities relating to sand mining include destruction of ecosystems, flooding, and collapsed bridges when the sand supporting the structure disappears.⁹⁸ Additionally, communities are experiencing a lack of access to clean water, loss of land, reduced access to food, and loss of vegetation.⁹⁹ Due to the increase in sand mining and the disappearance of beaches, the crab and fish supply in Cambodia have dramatically decreased, thus affecting the livelihoods of local fishermen.¹⁰⁰

90. GRUBER, *supra* note 10, at 3.

91. Jutlah, *supra* note 87.

92. GRUBER, *supra* note 10, at 123.

93. An example of an externality is pollution. COOTER & ULEN, *supra* note 40, at 39.

94. Jutlah, *supra* note 87, at 11.

95. COOTER & ULEN, *supra* note 40, at 39.

96. PADMALAL & MAYA, *supra* note 17, at 46.

97. GUNARATNE, *supra* note 48, at 202.

98. Romig, *supra* note 34.

99. PADMALAL & MAYA, *supra* note 17, at 46.

100. Chris Arsenault, *Cambodia Digs into Sand Mining Industry as Beaches and Crabs Vanish*, REUTERS WORLD NEWS (Nov. 3, 2016), <https://perma.cc/K5BF-2LBD>.

1. Solutions for Externalities: Privatization and the Coase Theorem

There are two main possibilities to solve negative externalities. The first is through privatization of the resource.¹⁰¹ The second is through government intervention.¹⁰² The main goal for solving an externality is to internalize the social cost.¹⁰³ This means that either private parties or the government takes some action so the price of sand reflects the external cost of mining it.¹⁰⁴

The first possible solution to mitigate externalities is privatization.¹⁰⁵ Suppose that an individual or a small group of individuals privately own a river and the underlying riverbed. Instead of the miners stripping the riverbed, which causes adverse environmental consequences, the owners of the river would negotiate with potential sand miners to determine the most efficient outcome for the parties.¹⁰⁶ This presupposes that the owners have a well-defined property right and that there are no transaction costs.

In an ideal world, privatization and well-defined property rights mitigate the negative externalities of sand mining. This solution would shift control of sand mining away from the government and to an individual or group who would efficiently maximize the utility of sand on their properties. This is commonly known as the Coase Theorem.¹⁰⁷ However, the current state of sand mining does not exist in an ideal world. It is not feasible to privatize sand and expect all of the parties to negotiate freely without transaction costs. Also, there is no guarantee that private

101. GRUBER, *supra* note 10, at 130.

102. *Id.* at 123.

103. *Id.* at 130.

104. *Id.*

105. In *The Problem of Social Cost*, Ronald Coase proposed that instead of government intervention, negative externalities can be mitigated with a market solution. The Coase Theorem has two major premises. First, there are no transactions costs and well-defined property rights, parties will reach the most efficient outcome in solving the negative externality problem. The second part asserts that it does not matter which party has the property right, just as long as one of the parties has the property rights, they will still reach an efficient outcome. *See id.* at 130–31.

106. This is commonly known as the Coase Theorem. The Coase Theorem has two main premises: first, when there are well defined property rights and zero transactions cost, then the two parties will reach the most efficient outcome, and second, it does not matter which party has the property rights, as long as one party has them. *See id.* at 131.

107. *See id.* at 131.

ownership of the resource would result in sustainability.¹⁰⁸ While the Coase Theorem applies to many scenarios, applying it to sand would be an oversimplification of the issue. The Coase Theorem may be able to mitigate externalities of sand mining within small communities, but sand mining has become a global issue, thus making privatization of sand infeasible.¹⁰⁹

2. Public Sector Solution: Government Intervention

Typically, government intervention cures market failure, either through regulation or taxation.¹¹⁰ Taxation affects the price of a good, while regulation affects the quantity.¹¹¹ When imposing a regulation or a tax, the government aims to achieve the lowest cost method to accomplish its goal, which in this case is the conservation of sand.¹¹²

a. Regulation

With reduction in quantity regulation, the government decides the optimal extraction amount in order for the regulation to not exceed the natural replenishment rate, the rate at which sand replenishes naturally.¹¹³ A blanket quantity restriction on sand is problematic because the different sand exaction sites have different replenishment rates. Even with the regulation in place, some sites would be more vulnerable than others. Regulation has a degree of flexibility through a permit system.¹¹⁴ Some countries have already instituted a permitting system.¹¹⁵ Similar to a cap-and-trade system, permits could be traded between one company selling its excess sand allocation and another company that needs additional sand. This would incentivize mining less sand by providing an opportunity to profit from less mining, thereby encouraging the use of alternative

108. Edella Schlager & Elinor Ostrom, *Property Rights Regimes and Natural Resources: A Conceptual Analysis*, 68(3) LAND ECON. 249 (Aug. 1992).

109. GRUBER, *supra* note 10, at 134.

110. *Id.* at 123.

111. *Id.* at 137.

112. *Id.*

113. *Id.* at 140.

114. *Id.* at 142.

115. See INDIAN MINISTRY OF ENV'T, FOREST, AND CLIMATE CHANGE, *Sustainable Sand Mining Management Guidelines* (2016), <https://perma.cc/FUC8-YSTG>; MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT DEPARTMENT OF IRRIGATION AND DRAINAGE MALAYSIA, *River Sand Mining Management Guidelines* (2009), <https://perma.cc/ZSQ4-MFK2>; Beiser, *supra* note 18; GUNARATNE, *supra* note 48, at 203.

materials. To avoid over-mining, the government would have to impose strong oversight controls and penalties for those disregarding their permits' allocations.

b. Corrective Taxation

Another possibility to cure market failure is corrective taxation. This imposes a tax on the party who created the externality and forces that party to internalize the cost of the externality.¹¹⁶ In practice, the tax is equal to the marginal damage caused by the externality.¹¹⁷ The theory is that a rational miner will continue to mine unless forced to assume the cost of mining.¹¹⁸ A corrective tax is not as limiting as a regulation on quantity.¹¹⁹ Comparing the methods of government intervention to cure market failure regarding sand, a tax or credit system might be more efficient than a regulatory scheme. If faced with a tax, mining companies would have a stronger incentive to find alternative materials.

B. Common-Pool Resources and Tragedy of the Commons

A common resource is property that is owned by the government, property not owned by anyone, or property owned by a community of resource users.¹²⁰ Commons problems occur when it is difficult to limit access to a resource.¹²¹ Individuals usually over-exploit the commons because they do not have a way of measuring the cost and benefit of each extraction, which leads them to use the resource at unsustainable levels.¹²² In a common-pool resource, owners are not the only users investing and improving the resource.¹²³

Individuals using a common resource rationally use the resource indiscriminately to benefit their own personal needs. Too many people using the resource leads to depleting the resource, thus preventing others from using it.¹²⁴ Generally, there are two methods to sustain the commons

116. GRUBER, *supra* note 10, at 134.

117. GRUBER, *supra* note 10, at 135.

118. Lee, *supra* note 41, at 480.

119. GRUBER, *supra* note 10, at 140.

120. Schlager & Ostrom, *supra* note 108.

121. Lee, *supra* note 41, at 480.

122. *Id.*

123. Schlager & Ostrom, *supra* note 108.

124. Lee, *supra* note 41, at 480.

over time: privatization or centralized government control.¹²⁵ A middle approach, between the extremes of government intervention and privatization, is community self-governance, which could solve the current sand mining problem.¹²⁶

Most environmental problems are governed by a top-down governmental regime, where the “top” sometimes has no idea what is actually happening with the resource in the community.¹²⁷ While international oversight is necessary for some environmental issues, such as pollution (which requires a cohesive global agreement on solutions), some environmental issues vary from community to community. Even though sand scarcity is a global issue, the specific environmental issues it creates vary greatly depending on the location.¹²⁸ Community-based governance systems may work in some communities, depending on the community’s geographical location and political regime.¹²⁹ In a community-based governance system, the community collectively has a vested self-interest in balancing the protection of the resource with the use of that resource, which benefits individuals and, in turn, the community.

There are two main reasons why the community-based governance theory is an appropriate solution for the sand shortage. First, sand scarcity, while a global issue, presents different challenges in different communities. The effects that sand mining has on a community depends on, among other things, the type of sand mined and local ecosystems.¹³⁰

Second, in the regions that are experiencing the harshest effects of sand mining, there is a growing problem with potential corruption and illegal mining at unsustainable levels. The community-based governance system shifts most of the control of the natural resource to community control rather than political control. The community has a personal interest in mining the sand sustainably so it is not depleted. Sand mining provides jobs to community members, which benefits the community as a whole. This provides the community the opportunity to build better infrastructure around the community with the sand. The effects of unsustainable sand mining on the community’s water and food supply, as well as the heightened threat of flooding, also provide the community with an incentive to protect their environment by protecting their resources.

125. Thomas Dietz, Elinor Ostrom & Paul C. Stern, *The Struggle to Govern the Commons*, 302 SCIENCE NO. 5652 1907 (2003).

126. *Id.*

127. *Id.* at 1908.

128. Gavriletea, *supra* note 14, at 14.

129. Dietz et al., *supra* note 125, at 1908.

130. Gavriletea, *supra* note 14, at 14.

For a successful outcome, the government would partner with the community-based governance system empowering, rather than discouraging, individuals like Abdulali. Both the national and the local governments would need to establish, through legislation, the conditions necessary for the communal governing system to work by enforcing the community's control over the resource.¹³¹ This system would limit corruption within the government, because the community would make most of the decisions regarding the use of the resource.

C. Initial Governmental Responses: Current Global Regulations

Globally, the policies governments adopt to combat rampant sand mining are inconsistent. The lack of cohesive and comprehensive policies lead to a strain on the supply of sand and adverse environmental and social issues.¹³² The current lackluster regulations also incentivize miners to participate in the black market rather than follow regulations.

Indonesia includes a land restoration fee in their permits required for mining activities. Sand miners avoid paying this fee by either not obtaining permits or by bribing government officials to mine more sand than the permit allows.¹³³ In Sri Lanka, sand is the property of the state, and miners must obtain a permit to mine and transport sand.¹³⁴ Sri Lanka banned some original supply sources of sand mining. Due to the ban, both prices and indiscriminate mining practices increased to meet the supply needs of the construction market.¹³⁵

Sand mining, unsurprisingly under this fractured regime, causes political tensions among neighboring countries.¹³⁶ The governments of Malaysia, Indonesia, Cambodia, and Vietnam banned the selling of sand to Singapore. They realized the negative effects of massive sand mining in their respective countries, but the complete ban on exporting sand only fueled illegal mining in Singapore and surrounding countries to meet Singapore's high demand. In Cambodia, the province of Koh Kong permanently banned sand mining in July 2017.¹³⁷ The Ministry of Mines and Energy investigated a trade discrepancy between Cambodia's exports

131. Dietz et al., *supra* note 125, at 1908.

132. GUNARATNE, *supra* note 48, at 202.

133. Beiser, *supra* note 18.

134. GUNARATNE, *supra* note 48, at 203.

135. *Id.* at 202.

136. Torres, *supra* note 76.

137. Ven Rathavong, *Sand Mining Stopped in Koh Kong*, KHMER TIMES (July 13, 2017), <https://perma.cc/CB2F-5U33>.

and Singapore's imports of sand during the same time period.¹³⁸ Cambodian government officials reported sixteen million tons of sand exported to Singapore, while Singapore reported receiving 72.2 million tons from Cambodia in the same period. To deter illegal mining and protect the environment, the Cambodian government only allows small-scale sand mining operations in Koh Kong to benefit local needs.¹³⁹ The Ministry of Mines also decided to investigate other areas where sand mining is popular to possibly ban mining in those areas as well.¹⁴⁰ Similarly, beginning in the 1960s, Japan banned river sand mining but still allowed marine sand mining.¹⁴¹

India classifies sand as a minor mineral, which means that mining regulations fall under the jurisdiction of the states.¹⁴² Different states approach regulation of sand and sand mining differently. For example, the Bengaluru¹⁴³ state government plans to completely ban sand mining by 2020.¹⁴⁴ The government wants to ban sand mining in hopes that it will stop the sand mafia and promote the use of manufactured sand (m-sand).¹⁴⁵ The Gujarat government contracts with companies to provide drone surveillance in areas with heavy illegal mining.¹⁴⁶

The Madhya Pradesh government takes a different approach to sand mining. Instead of banning mining completely, the government allows anyone to purchase a permit and mine in a designated area selected by the state.¹⁴⁷ The Madhya Pradesh government argues that this provides increased employment opportunities and affordable sand.¹⁴⁸ The government also implemented measures to prevent illegal sand mining with this program.¹⁴⁹ They plan to track all vehicles that enter and leave the approved mining sites and have stations for officials to check

138. *Id.*

139. *Id.*

140. *Id.*

141. Susan Froetschel, *Sand Mining: Growing Pains of Cross-Border Trade*, YALE GLOBAL (Aug. 29, 2017), <https://perma.cc/84E2-CKBG>.

142. GOV'T OF INDIA, *Guidelines for Sand Mining* (Dec. 15, 2016), <https://perma.cc/5VV7-M4WS>.

143. A city in India.

144. Ashwini Sripad, *Complete ban on river sand mining by 2020?*, NEW INDIAN EXPRESS (Mar. 19 2017), <https://perma.cc/MDN3-BEKY>.

145. *Id.*

146. Avinash Nair, *To curb illegal sand mining, govt opts for drones*, INDIAN EXPRESS (Aug. 24, 2017), <https://perma.cc/E8NB-HKVU>.

147. Suchandana Gupta, *Madhya Pradesh govt opens sand mines for all*, TIMES OF INDIA (Nov. 14, 2017), <https://perma.cc/SG58-GJDS>.

148. *Id.*

149. *Id.*

permits.¹⁵⁰ After the monsoon season, officials will also assess how much sand remains at these sites to protect against over-extracting.¹⁵¹

Even though states have jurisdiction over sand mining policies, India's national government is also trying to remedy the problem. In February 2012, the Supreme Court of India ruled that Ministry approval is required for all sand mining activities.¹⁵² In May 2012, the Ministry of Environment and Forests issued an order mandating that miners must comply with the Supreme Court's ruling.¹⁵³ In 2016, the Ministry of Environment and Forests issued Sustainable Sand Mining Management Guidelines.¹⁵⁴ In this report, the Ministry admits that sand is mined at unsustainable levels at a negative cost to the environment and ecosystems.¹⁵⁵

Domestically, governmental action with respect to sand mining also varies. Florida uses sand for land reclamation and beach re-nourishment projects.¹⁵⁶ Beach managers traditionally use offshore sand for these projects, but that supply is depleting.¹⁵⁷ Due to the high cost of mining sand inland and transporting it to the beaches, Florida proposed purchasing sand from the Bahamas.¹⁵⁸ However, importing sand from foreign countries violates the State's Water Resources Development Act of 1986.¹⁵⁹ In February 2017, the State House of Representatives introduced a bill referred to as the "Sand Act of 2017" to allow the State of Florida to legally buy sand from the Bahamas for various beach reclamation projects.¹⁶⁰

In California, the last coastal sand mine will close by 2020.¹⁶¹ After increased pressure from state and local entities, the Coastal Commission, the State Lands Commission, and the city of Marina reached an agreement

150. *Id.*

151. *Id.*

152. Jha K Manoj, *Illegal Sand Mining: Steps Taken by Government of India*, IAS SCORE <https://perma.cc/3U2X-WYYB> (last visited 2018).

153. *Id.*

154. INDIAN MINISTRY OF ENV'T, FOREST, AND CLIMATE CHANGE, *supra* note 115.

155. *Id.* at 9.

156. Henry Grabar, *South Florida, Out of Beach, Wants to Buy Sand from the Bahamas*, SLATE (Nov. 02, 2017), <https://perma.cc/QVR7-Q7AX>.

157. *Id.*

158. *Id.*

159. *Id.*; see also Water Resources Development Act of 1986, H.R. 833, 115th Cong. § 1 (2017).

160. See Water Resources Development Act of 1986, H.R. 833, 115th Cong. § 1 (2017).

161. Molly Melius, *Shutting Down the Last Coastal Sand Mine in the United States*, STAN. L. SCH. BLOG (June 30, 2017), <https://perma.cc/2E6E-WVS3>.

with CEMEX, the sand mining company, to continue mining at historical levels until December 2020.¹⁶² After the facility closes, CEMEX will begin a three-year reclamation project to clean up and restore the beach and the site surrounding the facility.¹⁶³

D. The Black Market and The Sand Mafia

The International Policy Digest's article on sand mining states it best: "Illegal Sand Mining is a Thing and it's A Problem."¹⁶⁴ A black market is a channel for economic activity to take place outside of government-sanctioned or regulated channels.¹⁶⁵ Black markets typically arise to avoid government intervention such as overregulation or prohibition.¹⁶⁶ If the government overregulates or prohibits a good, a black market for this good will likely form.¹⁶⁷

Governments have tried to limit or completely outlaw sand mining because of the negative externalities it imposes on the environment, river structures, and ecosystems. However, due to corruption, selectively lenient regulation, and prohibition, there is a growing black market for sand.¹⁶⁸ It is more profitable for miners to break the law and mine at night than follow the regulation and try to get a permit.¹⁶⁹ The "sand mafia" is a big contributor to sand's black-market supply.¹⁷⁰ This is dangerous, not only because the sand mafia is killing people in order to access rivers and beaches, but because there is no way to know how much sand is actually being mined and what processes the miners are using.¹⁷¹ Illegal sand mining is more dangerous and is fueling the shortage of sand more so than legal mining.¹⁷²

There are three distinct types of illegal sand mining.¹⁷³ The first type involves miners with permits, who over-extract beyond what their permits

162. *Id.*

163. *Id.*

164. Christian Hellwig, *Illegal Sand Mining is a Thing and it's a Problem*, INT'L POL'Y DIG. (Apr. 2015), <https://perma.cc/Z8ZP-RW3R>.

165. *Black Market*, INVESTOPEDIA <https://perma.cc/55XU-Y5A7>.

166. *The Mechanics of the Black Market*, INVESTOPEDIA <https://perma.cc/XS8U-AEH7>.

167. An example of government over regulating and the creation of a black market because of it is the sale of alcohol during prohibition.

168. Peduzzi, *supra* note 5.

169. Romig, *supra* note 34.

170. Peduzzi, *supra* note 5.

171. *Id.*

172. Romig, *supra* note 34.

173. See GUNARATNE, *supra* note 48, at 204; Beiser, *supra* note 18.

allow.¹⁷⁴ The second type involves miners not obtaining permits and mining the sand from river beds by digging it out themselves with simple tools.¹⁷⁵ The third, and most dangerous type, involves the sand mafia.

In Sri Lanka, to keep up with increasing demand, some miners have turned to illegal mining. A third of the demand for sand in Sri Lanka is met by illegal methods.¹⁷⁶ There are two main types of illegal miners in Sri Lanka: miners who have permits but over-extract sand and miners who extract sand from banned sites.¹⁷⁷

The average price of sand in Singapore was three U.S. dollars per ton. After Indonesia banned sand exports, and the other neighboring countries, Malaysia and Cambodia, either banned or exported fewer amounts of sand, the price of sand increased to 190 U.S. dollars per ton.¹⁷⁸ The ban from Singapore's neighboring countries increased illegal mining activity to keep up with the country's high demand.¹⁷⁹ To cover up illegal mining from Cambodia, Singapore misreports imports of sand.¹⁸⁰

While Vietnam banned exports of sand as well, there is still a high demand for sand for domestic construction purposes.¹⁸¹ Licensed sand mining can only meet 60% to 65% of the country's demand for sand for construction purposes alone.¹⁸² Illegal sources are used to meet the remaining demand.¹⁸³

In India, people are looking to the courts to stop illegal sand mining. Since 2014, there have been around 9,000 cases against individuals for illegal sand mining and transportation.¹⁸⁴ India is trying to combat illegal sand mining by fining companies who mine sand illegally, opening investigations on illegal miners, and bringing them to trial.¹⁸⁵ There are proposals to set up a royalty program based on the amount of mining conducted and implement special permits to transport sand within and

174. GUNARATNE, *supra* note 48, at 220.

175. *Id.*

176. *Id.*

177. *Id.* at 204.

178. Peduzzi, *supra* note 5, at 8.

179. *An Improbable Global Shortage: Sand*, ECONOMIST (Mar. 30, 2017), <https://perma.cc/L9YE-4HJ8>.

180. *Id.*

181. Nhan Dan, *Construction ministry asked to stabilise local sand market*, NHAN DAN ONLINE (Sept. 20, 2017), <https://perma.cc/J75M-AYSE>.

182. *Id.*

183. TUOI TRE NEWS, *supra* note 84.

184. Sripad, *supra* note 144.

185. Ivan Loh, *Dr.Mah: Illegal Sand Mining Activity Reduced to About 30%*, The Star (July 2, 2015), <https://perma.cc/3MDE-E5PY>.

outside of the state.¹⁸⁶ While India was successful in cutting illegal sand mining from 70% to 30%, illegal mining still has a very large impact on the nation.¹⁸⁷

IV. SOLUTIONS TO SAND SHORTAGE

A. Ideal Regulation and Taxation Structure

Banning sand mining in its entirety is not a practical solution. A complete ban would be counter-productive to the growth of developing nations' economies and would further incentivize the black market. Each government should consider three things when contemplating a regulatory structure. First, before developing a regulatory structure, officials should study the environmental and economic effects of sand mining on their area. Second, with the information gathered, legislators should find a sustainable level of mining that does not permanently harm the environment. This legislative process includes the opportunity to develop new technology to mine sand more efficiently or to find alternative resources. Finally, policymakers should consider how proposed regulation or taxation schemes would possibly incentivize or disincentivize illegal mining.

An ideal regulatory framework would promote and provide credits to companies hiring locals. Individual sand mining creates jobs and helps grow the economy in small, rural villages. Providing adequate compensation to individual miners curbs the incentive to turn to the black market. Ideally, under this regulation, the rational individual would mine sand legally for his own benefit. Such regulation would also make it economically unattractive for individual miners to turn to the black market, thus slowly pricing out the black market.

Additionally, while implementing a tax system could potentially extinguish the negative externalities of sand mining, it could also potentially force the industry to shift from using sand to other resources that would be more profitable.¹⁸⁸ Governments could issue a credit for large mining companies that employ locals from the community and a corrective tax based on extraction rates and the location's vulnerability. The corrective tax revenue would provide funding to a conservation fund to mitigate the negative externalities of sand mining. Also, tax credit

186. *Id.*

187. *See also*, Smriti Kak Ramachandran, *Sand mining issue: "Impact cannot even be calculated,"* HINDU (New Delhi) (June 2, 2016), <https://perma.cc/X2PB-2ZQT>.

188. Gavriletea, *supra* note 14, at 18.

incentives would encourage companies to seek alternative materials, thus shifting the demand away from sand.

B. The Problem: Government Failure

Government intervention is sometimes necessary to cure market failure; but, in the case of sand, government intervention in certain countries does not deter illegal sand mining and instead fuels the practice.¹⁸⁹ The sand mafia bribes government officials in India so they can continue their practices.¹⁹⁰ Officials in Singapore misrepresent the number of sand imports so the country will not escalate the conflict with neighboring countries over illegal mining.¹⁹¹ These are examples of government failure. Government failure occurs when governments intervene to solve a market failure but instead create inefficiency and a misallocation of resources.¹⁹² While a comprehensive regulatory and taxation scheme would be ideal to implement on an international level, due to local government corruption, it may not be possible. Facing this government failure, there is an optimal solution to conserve sand and combat corruption.

The traditional approach to solving the tragedy of the commons, such as the over-mining, is privatization¹⁹³ The theory is that, if there are well-defined property rights, individuals will act rationally to protect or preserve their resources in a way that is valuable to them. There is another approach that does not involve private property or extensive governmental regulation and oversight: This approach is the community-based governance approach, and it suggests that a community could come together, inform itself of the problem, and establish its own regulations and enforcement within its community.¹⁹⁴ This approach is really only useful in small, rural communities with a common-pool resource.¹⁹⁵

An ideal solution for a small, rural community to reach is one that does not completely ban sand mining and does not over-exploit the resource. This solution also combats the government failure experienced by countries with corrupt governments. Private property solutions to fix the commons

189. *Government Failure*, ECONOMICS ONLINE, *supra* note 43.

190. See Meynen, *supra* note 1; see also, Sandhya Ravishankar, *Two Decades Saw Corruption in Centre and State, Says Report on T.N. Beach Sand Mining*, HINDU (New Delhi) (July 10, 2017), <https://perma.cc/QS93-876A>.

191. *An Improbable Global Shortage: Sand*, ECONOMIST (Mar. 30, 2017), <https://perma.cc/TE8M-H5EU>.

192. *Government Failure*, Economics Online, *supra* note 43.

193. Dietz et. al., *supra* note 125, at 1907.

194. *Id.*

195. Ilg, *supra* note 12, at 81–82.

problem only work when there are well-defined property rights enforced by the government and societal norms. When private property rights are not enforced, a community-based governance system serves as an alternative solution. By taking control of its own resources, the community can profit from limited sand mining while understanding that it needs to preserve the resource for its economic, as well as environmental, benefit. Tying the community's livelihood to the sustainability of the resource, the community is more likely to police for illegal mining and promote sustainability.

There are two main reasons why the community-based governance theory is appropriate to apply to the sand shortage. First, sand scarcity, while a global issue, presents challenges in different ways in each community. Depending on the type of sand mined and the local ecosystems, the effects sand mining can have on a community vary.¹⁹⁶ It is difficult for a country to establish a blanket rule that applies to every local community because each community is different; thus a community-based governance system would allow each community to tailor regulations to fit the needs of the individual community.

Second, in the regions that are experiencing the harshest effects of sand mining, the local politicians tasked with enforcing the rules are corrupt, accepting bribes and allowing illegal mining at unsustainable levels.¹⁹⁷ The community-based governance system shifts the control of the natural resource to community control rather than political control. The government's sole job in this situation is to help the community enforce its rules. Local politicians may have an incentive to accept the bribes instead of enforcing the law, but it will be more difficult for illegal miners to win over a community that has an interest in the natural resource. The community has a personal interest in mining the sand sustainably so they do not run out, because the sustainability of sand is tied to community members' economic livelihoods. Sand mining provides jobs to community members, which, as a whole, makes the community better off, and it provides the opportunity to build better infrastructure around the community with the sand. The effects of unsustainable sand mining on the community's water and food supply, as well as the threat of flooding, also provides the community with incentives to protect their resources.

There are, however, downsides to this system. While community-based governance has been successful in some cases, it has also failed.¹⁹⁸ There are five requirements for a community to have a successful

196. Gavriletea, *supra* note 14, at 14.

197. See Beiser, *supra* note 18.

198. Dietz et. al., *supra* note 125, at 1908.

governance system.¹⁹⁹ The five requirements are: (1) the use of the resource can be monitored, and information can be gathered and understood at a low cost; (2) the rate of change of the resource is moderate; (3) communities maintain effective communication; (4) outsiders can be excluded at a relatively low cost from the resource; and (5) the community and users monitor the resource and enforce the rules.²⁰⁰ Very few communities meet these criteria.

The challenge is for governmental institutions to create the conditions to have a successful governance system within the community.²⁰¹ As the criteria relate to sand, the first and the fourth factors pose the most problems. One of the largest issues regarding sand mining is that it is hard to monitor the resource and gather that information.²⁰² It is currently unknown how much sand, legally and illegally, is mined from a specific site.²⁰³ The best way of determining how much sand is mined is by calculating how much cement is produced; but that does not capture the full picture because construction only covers one use of sand.²⁰⁴ Additionally, it is difficult to prevent individuals from mining the sand because it is a common resource.

Despite the previously mentioned issues with the community-based governance model, this solution is still an option to combat illegal mining and political corruption in certain areas. Of course, the community cannot enforce its practices alone. It would also need assistance from the government to create a system fostering communal governance. Community-based governance is an unorthodox solution to a commons problem, but it is not a viable solution for every community.

C. *Alternative Materials*

Another option to meet the increasing demand for construction without over-exploiting sand is using alternative building materials. There are a few materials that can replace sand as an aggregate. The first is fly ash which is a byproduct of burning coal.²⁰⁵ In the Netherlands, almost all

199. *Id.*

200. *Id.*

201. *Id.*

202. *See* Peduzzi, *supra* note 5, at 7.

203. *Id.* at 1.

204. *Id.*

205. Michel Robles, *Urban Mining for Sand and Gravel*, DUTCH WASTE MGMT. ASS'N (May 2017), <https://perma.cc/39ET-8HUT>.

of the fly ash from coal-powered plants is used as an aggregate for cement and concrete.²⁰⁶ The use of fly ash also prolongs the life of concrete.²⁰⁷

The Netherlands realized that construction and demolition industries created a lot of waste; however, Dutch construction companies started to use concrete waste in the construction process.²⁰⁸ They found that recycled aggregate has benefits over sand.²⁰⁹ The European Union even requires countries to recycle 70% of their construction and demolition waste, promoting the use of recyclable materials instead of sand.²¹⁰

Crushed plastic can also be used to replace a percentage of sand in the building process.²¹¹ Researchers are currently exploring different combinations of sand and plastic as an aggregate to create cement strong enough for load bearing walls.²¹² Finally, manufactured sand (m-sand) is another alternative aggregate. Creating m-sand involves crushing stones into aggregate until it meets the required grain size. It must be washed and screened to eliminate dust particles.²¹³ Some developers have completely substituted m-sand for river sand in their projects, which they claim improves the project's efficiency.²¹⁴ While it takes more work to make m-sand than mining river sand, some experts say, when made correctly, m-sand is just as good as river sand.²¹⁵

In its 2016 report, India's Ministry of the Environment and Forest suggested the use of m-sand to reduce the consumption of river sand.²¹⁶ M-sand may or may not be as good as natural sand; however, it meets the building code requirements of the Indian government, and it is more environmentally friendly than using natural sand.²¹⁷ There is also a push

206. *Id.*

207. *Id.*

208. *Id.*

209. *Id.*

210. *Id.*

211. *Development of Structural Concrete with the Help of Plastic Waste as Partial Replacement for Sand*, U. OF BATH, <https://perma.cc/8U8J-PJU2> (last visited Oct. 15, 2017).

212. *Id.*

213. M.L. Mahesh, *All in a Grain of M-sand*, HINDU (New Delhi), (Sept. 12, 2015) <https://perma.cc/TVS2-KWHG>.

214. Naren Karunakaran, *How Manufactured-Sand is Helping Reduce Indiscriminate Sand Mining and Saving Riverine Ecosystems*, ECON. TIMES (Dec. 24, 2015) <https://perma.cc/WL9K-3HJQ>.

215. Mahesh, *supra* note 213.

216. INDIAN MINISTRY OF ENV'T, FOREST, AND CLIMATE CHANGE, *supra* note 115.

217. Sripad, *supra* note 144.

to use waste for building material.²¹⁸ The Indo-UK Centre for Environment Research and Innovation identified specific types of agricultural and industrial waste from India that can be used as aggregates in the construction process.²¹⁹ Not only will this decrease the demand for sand specifically in regions with a low supply of natural resources by providing a substitute, but the recycling of material will also decrease India's waste.²²⁰

On a larger scale, an international regulatory body can implement policies to promote the use of alternative materials, or clean construction, and bring an overall awareness to the issue. Governments should combat illegal sand mining and promote sustainability. Governments should either create a tax or permit system that has stronger oversight to police for local government corruption or switch most of the resource decision-making to the communities where mining takes place. Either way, the government and the local communities need to work together to establish the most efficient system to learn more about the harmful effects of sand mining, to create a system or implement technology to mine sustainably, and to decrease illegal sand mining and political corruption.

CONCLUSION

As developing nations grow, there is a higher demand for construction to build infrastructure and buildings. However, the type of sand required for this construction is a finite resource, and, as urbanization increases, the supply of sand decreases. Sand mining creates many environmental issues. Coastlines are eroding, and ecosystems are vulnerable to disturbance. While governments have tried to control sand mining to mitigate environmental concerns, the sand mafia has taken over and created a black market. While bribing government officials and the police to allow their activity to continue, the sand mafia mines the sand at night.

218. Nimisha Tripathi, *Construction: Use Waste for Building*, NATURE, (Oct. 26, 2017) <https://perma.cc/WWH9-N8PA>.

219. *Id.*

220. *Id.*

An inefficient allocation of resources in a free market causes market failure. To fix a market failure, government intervention is the solution. Ideally, the government would promote a regulatory structure that promotes the positive sides of sand mining, such as job creation, while also limiting the negative externalities of illegal sand mining and environmental damage, thus effectively bringing sand mining and construction practices “out of the dark.”²²¹

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221. Romig, *supra* note 34.

* J.D./D.C.L. 2019, Paul M. Hebert Law Center, Louisiana State University. The author would like to thank Professor John Church and Professor Philip Hackney for their assistance with this Comment. She would also like to thank her parents and friends for their continued support and encouragement through this process.