INNOVATIVE TECHNOLOGIES TO ADDRESS THE RESOURCE CURSE: A CASE STUDY OF ILLEGAL SAND MINING IN MADHYA PRADESH INDIA

By

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AUTHOR'S DECLARATION

I, the undersigned **Setu Bandh Upadhyay**, hereby declare that I am the sole author of this thesis. To the best of my knowledge, this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted as part of the requirements of any other academic degree or non-degree program, in English or in any other language.

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ABSTRACT

The resource curse thesis argues that regions with an abundance of natural resources are likely to be underdeveloped. The idea took shape in the 1980s, but since then the technology has made pronounced strides and has presented solutions to several of the global challenges while contributing to human development. This thesis explores the question of whether this leap in the development of innovative technologies can be deployed in such a way that the resource curse becomes a thing of the past. Sand being highest extracted natural resource only second to water has become a visible exhibit of the resource curse in developing regions. The thesis examines a case study to explore this argument, a case study of illegal sand mining in Madhya Pradesh state of central India, examining the case from a policy perspective considering its implications. The implications are not only environmental but also have long term socio-economic consequences, which are ticking bombs in the form of generational poverty and unsustainable development. The thesis explores the potential technological solutions and their use as policy interventions as initial steps to solve the problem are discussed, keeping in mind their viability and applicability to this particular case while exploring if the solutions are replicable for other resources.

Keywords: Resource Curse, Technology, Sand, Illegal Mining, Blockchain.

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And lastly, I would like to give myself a pat on the back for making it through.

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INTRODUCTION

"In every grain of sand, there is the story of the earth" - Rachel Carson

According to the resource curse thesis, the regions with an abundance of natural resources tend to have lesser economic growth and worse outcomes when it comes to development. The idea has been dubbed as the "paradox of plenty" and is derived from the studies of the regions which are an abundance of natural resources like oil or minerals (Venables 2016; Ross 1999). Sierra Leone and its diamonds, Democratic Republic of Congo and its metals are recent and ongoing exhibits of this paradox (Stevens and Dietsche 2008).

The abundance of resources is often a driver of conflict leading to unstable institutions; ineffective governance mechanisms leading to restricted and unequal economic growth and therefore, the crooked path towards development, which is not sustainable. Sand as a resource is exhibiting the same interest as other resources which were initially included in the idea of the resource curse (Billon 2013). The lack of awareness about the importance of sand, as well as the extent of the problem, has led us to turn a blind eye towards this issue. Sand is an essential ingredient for many industries, including concrete, glass, and electronics. Extraction of sand has exceeded fossil fuels and biomass. The absence of data on sand mining makes assessment incredibly difficult and thereby leading to a lack of awareness on this issue (Kukreti 2017). The increasingly growing demand for sand can be credited to the developing countries where rapid economic growth has fueled the construction industry. This spike in construction activities has led to a growing demand for river sand exponentially (Pearce 2019).

India is a newly industrialized country with immense infrastructural growth and ever-growing demand for more of it, needs more and more sand every year. India is urbanizing at such an immense scale that it is virtually unmatched by any country in history. High rise apartments,

ambitious highway projects, bridges, metro systems, dams: Each of them devours an incredible amount of sand. According to a research every residential house requires around 200 tons of sand and while larger buildings require approximately 3,000 tons of sand and on the other hand a kilometer of highway according to government standards require 30,000 tons of sand (Delestrac 2012).

Jawaharlal Nehru, the first Prime Minister of India, coined the term "temples of modern India" for the dams (DNA 2009). It is the ever-growing need for power coupled with this national vision led to the construction of nearly 5264 large dams in India. A large dam is defined as the one with a height of at least 15m from its deepest foundation to the crest. These dams provide electricity and water security to millions, but on the other hand, are responsible for destroying the natural habitat of several species and trapping the naturally flowing sand (CWC 2018).

This demand has led to a tremendous increase in the extraction of sand from not only quarries but also from riverbeds using dredging. Research suggests that in-stream sand requires minimal processing and is ready for immediate use while giving high-quality outputs compared to its marine counterparts (Kondolf 1997).

The state of Madhya Pradesh in central India is one of the worse affected by Illegal sand mining. Prolonged sand mining from Chambal, Sindh, Betwa, Ken, and Narmada rivers have caused irreparable damage to them as well as their surrounding regions and tributaries. The effect is not only environmental but also has socio-economic consequences with impact on agriculture, trade, transportation, health, education, and employment (Kumar 2018).

The state has a history of violent conflict over resources in multiple regions which ranges from internal insurgencies to dacoits with numerous attacks on government officials, law enforcement bodies and members of the press. The illegal sand mafia has adopted the violence

from historical conflicts in the region but with collaboration with stakeholders, in this case, leading to a failure to stop the illegal sand mining by the government (Rawat 2019).

The exploitation of natural resources is resulting in adverse effects on the environment, such as sliding of river shores and lowering the water table. This supply-demand mismatch has led the construction industry to switch tactics and procure sand illegally. There are multiple reasons for that: not only the illegally mined sand is cheaper, but also it is easy to access and transport as sand is very heavy mineral which makes it expensive to transport. Construction companies, therefore, choose to buy and use the illegally extracted sand not just because it's cheaper to get and transport but also because of its ease of availability which is why the proximate source is often preferred over the ethical source (Romig 2017).

Sand is the most mobile resource on earth and is present and used in our everyday lives more than we realize. From roads, reclamation, gas extraction, beach nourishment, glass to computer chips, everything requires sand (Torres et al. 2017). The sand hungry constructing industry is unable to quench its thirst from the desert because of nature's irony. Construction requires angular and rough sand so that it can bond with cement and other elements, desert sand, on the other hand, is smooth and round due to years of polishing against other sand grains and is therefore known as "bad sand" in the construction industry (UNEP 2014).

All sand is formed in either high up in the mountain or from the eroded rock in the river's delta and is supposed to end up at a shoreline if there was no human interference. But since human interference is the root cause of the problem today, about 50% of the sand which should naturally flow in the river will never reach the sea because of river dredging (Kondolf et al. 2014).

Approximately 59 billion tons of mineral is mined every year out of which sand and gravel account for the highest and fastest extraction (Steinberger, Krausmann, and Eisenmenger

2010). The exact data of sand mining is unavailable, which has further led to a lack of awareness of this issue. Research suggests predicting approximate sand usage can be calculated based on the production and usage of cement. Construction being the dominant force behind the demand for sand, is used by mixing it with cement, water, gravel, and sand to make concrete (Krausmann et al. 2009). In 2015, 4.1 billion tons of cement was produced by 150 countries (USGS 2015). The ratio of cement to sand for construction purposes is about 1:6, which means that approximately 25 billion tons of sand were used by the construction industry in 2012 alone: Enough to build 27 meters by 27 meters wall around the equator (USGS 2013).

This estimate added with sand consumption in other industries including reclamation, embankments and manufacturing exceed more than 40 billion tons every year which is more than double the amount of sand which is naturally flowing sediment of all the rivers in the world combined (Milliman and Syvitski 1992). This disproportionate amount of sand mining leads to a drastic impact on biodiversity, water turbidity, water table, and the surrounding landscape while adding carbon burden from the transportation of the extracted sand (Saviour 2012). The transport of these vast amounts of illegally mined sand over long distances often over state lines has a direct impact on greenhouse gas emissions. Research shows that the indirect impact of sand mining come from the production of cement and for every ton of cement, an average of 0.9 ton of carbon dioxide is produced (Mahasenan, Smith, and Humphreys 2003). Total carbon dioxide emissions from the cement industry amounts to approximately 29.3 billion tons, indirectly contributed from sand mining (Stocker et al. 2013). On top of the environmental consequences of sand mining, there are cultural, political, and most importantly, socio-economic consequences (J and R Anilkuar 2014).

The current demand trends been changing and increasingly and can be partially attributed to the rapid economic growth in Asia, particularly in China and India. About 70% of total global

cement production is by five countries: China (56%), India (11%), United States (2%), Brazil and Turkey. These figures clearly indicate that China, followed by India, are spiking the global demand for sand (USGS 2015).

The thesis explores potential technological solutions which can be employed as policy interventions to address and soften the blow of the resource curse. As exhibited above, sand extraction in Madhya Pradesh checks all boxes for the "paradox of plenty". Combined with declining economic growth and increasing unemployment, it's a ticking bomb, explosion of which leading to generational poverty in the region (Gal 2014).

The thesis examines the choice of case and the methodology used to analyze the policy issue. The applicability of the theory of resource curse is touched upon after discussing the extent of the problem with its nuances and intestacies. The drivers of conflict, sand mafia and economics are discussed. A stakeholder analysis is conducted based on the background through the literature and the observations from the field. The observation comprises of data from elite interviews and visual observations. The stages of illegal sand mining are examined, followed by a document analysis of existing and previous policies have also been conducted to determine the discrepancies and loopholes in the policy. The thesis further explores the potential technological solutions which can be used as policy interventions in the case of illegal sand mining and can potentially be replicable in other cases via policy transfer. The thesis provides policy recommendations as initial steps to tackle this issue based on the feasibility of potential solutions and concludes with a roadmap of the solution to the problem.

CHAPTER 1 – RESEARCH METHODOLOGY AND DESIGN

1.1 Case Selection

The case of illegal sand mining in the state of Madhya Pradesh was chosen because it is one of the 12 states which is publicly known mining hotspots and is one of the worst affected regions in India when it comes to sand extraction. The state provides environmental clearance for sand mining where mining areas are not demarcated. Therefore, mining far exceeds the allotted area. A strong nexus between contractors, politicians, and bureaucrats facilitates illegal mining particularly rampant in Narmada river basin. (Shrivastava et al. 2015).

The familiarity of language and the local context, Madhya Pradesh being my home state allowed me to dive deeper into the nuances of subtle cultural cues and behaviors which influences the choice of individuals in the region, allowing me to understand the root causes of the problem as well as switching lenses to understand the problem and possible solutions from multiple perspectives.

Since cases in qualitative research don't tend to be unique and this region has shown similar characteristics like other places known for rampant sand mining, the possibility of selection bias in the case selection and its effect on the research outcome is minimized (Gerring 2008).

1.2 Theoretical Framework

Developing and newly industrialized countries have repeatedly and regularly faced the dilemma of using their natural resources to improve their economy. The dilemma comes from a multifaceted problem, which is not only economic but also political in nature. Utilizing the natural resource is a multistage economic and political problem that requires participation of

multiple stakeholders: private investment to extract the resource, fiscal management to secure the revenue, sagacious government investment and spending, all the while designing policies to manage social and economic instability and mitigate adverse impacts the economy as a whole (Venables 2016). The Madhya Pradesh illegal Sad Mining case fits the bill perfectly with all the factors playing out without consideration of above-mentioned variables.

The case exhibits the characteristics of the Dutch Disease along with traditional characteristics of the "paradox of plenty". Dutch Disease describes the causal relationship between the increase in economic development in one sector (Sand Mining in this case) and an apparent decline in other sectors (Agriculture) (Corden 1984).

It has been argued that strong, transparent and democratic institutions can turn around the resource curse into a blessing in resource-rich economies, stimulating economic growth while generating public awareness about the resource, its benefits, and drawbacks (Kaznacheev 2017). The theory has, however, not been tested on regional economies, but the case shows a promising change if the right policy interventions are deployed based on the observations and analysis.

The concept of sustainable development also plays a crucial role in this case and in all other cases of the resource curse. The widely used term which acts as a catchphrase in the development sector, the idea behind which is to meet the required human development potential while ensuring the ability of natural systems to provide the resources upon which the society and the economy depend on for the aforementioned growth (Lélé 1991). Sand mining is a classic example of the unsustainable development, given the fact that a critical factor to economic growth is infrastructural development which fuels the construction sector, which in turn devours sand by disproportionate amounts.

1.3 Research Question

How can technologies be harnessed in such a way that they can address the resource curse? This question will focus on harnessing the innovative technologies in ways in which the resources can be used for sustainable and equitable human development. Since the projection of the resource curse, the technologies have made strides and improved significantly. Moore's law which observed that the number of transistors in integrated circuits double every year (Keyes 2006). This advancement is as significant as other aspects of technological progress like speed, accuracy or price or electronics which have been linked to Moore's law, implying technology is "*getting better at getting better*" (Kurzweil 2006).

1.4 Research Design

To understand the complex and sophisticated phenomena, in this case, a research design consists of qualitative methods along with policy analysis tools. Elite interviews were conducted with various stakeholders, which was critical to obtain a multi-stakeholder perspective. Elite interviews are chosen by name or position for a particular reason, rather than randomly or anonymously (Draper 2001; Hochschild 2009). The data gathered in these interviews was cross-checked or verified for authenticity to minimize biases of the interviewees.

The stakeholder analysis was conducted based on the observations of the semi-structured positivist interviews which allowed for the conversations to be guided towards the right direction while leaving an open end for some information which might have been missed. Stakeholders were first identified, differentiated, and categorized, and then the observations were used to determine the interests, obstacles, gains, losses, and overall implications to them. A stakeholder analysis defines the aspects of a social and natural phenomenon affected by a

decision or action while identifying individuals, groups and organizations who are affected by or can affect those parts of the phenomenon all the while prioritizing these individuals and groups for involvement in the decision-making process (Reed et al. 2009). Stakeholder analysis gave way for the differences of opinion among the stakeholders providing an in-depth understanding of the context which can be employed in designing the intervention (Majchrzak and Markus 2014). The interviews were conducted in Hindi - being the official language of the state and the language people are more comfortable speaking. The interviews were transcribed and translated into English for the purpose of analysis for this thesis. Elite interviews, of manual sand miners, the sand mafia boss, local farmers, village officials and officials of mining department and revenue department of state of Madhya Pradesh were conducted. These interviews provided a comparative perspective from different stakeholders of the problem which aided in the determination of loopholes in the existing policy and recommended interventions keeping in mind the concerns of all the stakeholders (Manzano 2016).

Further, a document analysis of the existing policy on sand mining in Madhya Pradesh is also conducted along with legislation related to mineral mining in the state. This was done to find out where are the missing linkages between the regulatory mechanisms and the ground reality discovered through elite interviews and stakeholder analysis (Bryman 2012).

The literature review is done in text instead of a separate section to allow derivation from the literature during analysis as well as for ease of understanding the context and the intricacies of the problem and the case. In text literature review also facilitated in keeping the focus on the pragmatic approach to the issue without moving away from the theories (Webster and Watson 2002).

CHAPTER 2 – BACKGROUND AND OBSERVATIONS

2.1 Sand Mafia: Organized Crime

The sand mafia in India works just like an elaborately organized crime syndicate. The structure if hierarchical with dangerous criminals and politicians on top profiteering off as suppliers of a commodity high in demand. Sand Mafia is one of the most influential and vicious criminal organizations in India, which has its webs across all strata of society. Studies suggest that the people who are involved in sand mining are also the people involved in the activity which consumes the highest amount of sand: construction (Rege and Lavorgna 2017). The sand mafia is currently considered to be one of the most prominent perilous, violent and, impenetrable organized crime groups in India which enables and aids illegal sand mining for construction and generates approximately 17 million US dollars in revenues per month (Keelor 2013).

A key issue in dealing with Sand Mafia is recognition. The government or judiciary has failed to acknowledge and recognize the extent of its operation and has not declared the operation as organized crime.

> According to Section 2(a) of the United Nations Convention against Transnational Organized Crime, 2003, an organized criminal group is defined using the following four criteria:
>
> 1. A structured group of three or more persons;
> 2. The group exists for a period of time;
> 3. It acts in concert with the aim of committing at least one serious crime;
> 4. To obtain, directly or indirectly, a financial or other material benefit (UNODC 2003).

The above-mentioned definition has been ratified by India under the convention and yet there has been a consistent lapse of judgment on the state's part in its failure to recognize the operations as organized crime.

The collateral damage from the sand mafia is not only environmental but also physical and economical. The mafia operates in a sophisticated system which involves multiple actors from local farmers, law enforcement agencies, government departments, politicians, and construction companies. The mafia operates as a fragmented structure with ephemeral memberships and relies on political affiliation and violence for their regular operation. The organization is known for inflicting physical harm to those who stand in its path, including several law enforcement officers, media persons and, locals in an effort to incite fear among the public to speak out against them (Naveen 2018).

The mafia is also responsible for several involuntary death due to accidents while mining and transporting the illegally mined sand. Inadequate manpower, rapid economic development, weak enforcement mechanisms, and limited acceptance of alternative to sand has led to this monumental rise of sand mafia. Questions have been raised about why sand mafia was born and still exists, and the answer lies with several developmental challenges in rural India such as unemployment, and lack of education and awareness.

2.2 Elite Interviews

The elite interviews of multiple stakeholders have been conducted and analyzed with the observations. These stakeholders included sand miners, a sand mafia boss, farmers, village officials, district administration officials, a representative from a registered mining company and a site manager of a construction company. For the purposes of individual anonymity quotes, transcripts and statements are not revealed and the findings of the elite interviews are

compiled with observations are presented as one after the collection of different perspectives of stakeholders to paint a picture which is neutral and closest to reality. The data gathered from the interviews have been clubbed with observations while the findings have been verified and supported by either the existing literature or with observations on field.

2.3 Observations and Effects

In conversation with stakeholders who are involved in the mining operations for more than 10 years in some cases, several things which seemed unclear at first came to light. The dialogue not only shed light on how activities take place but also revealed the underlying causes as well as potential solutions to the problem. The data from the observations and interviews are collected by field research at Harda district, Hoshangabad district and Sehore district in central Madhya Pradesh where the illegal sand mining is rampant on the river Narmada, and it's tributaries.

One of the sand mine along the borders of the districts of Hoshangabad and Harda is the biggest sand mining hotspot in the state which spans around 12 kilometers and has been excavated continuously for the last 15 years. But the last five years have proven to be catastrophic for both the Tawa and Narmada rivers which are not only the primary sources of water in the region but also a source of indirect economic growth. Since most of the sand had already been mined from the banks, and now the sand is being excavated from the riverbed through dredging using excavators or by divers on small boats manually. This has led to an empty river for the most part of the year except in the monsoon season in which the flash floods have been getting bigger and increasing every year because the water does not stop since there is no sand which acts as a barrier and a guide to flowing rivers. There are three kinds of sand available in this particular hotspot; all three of them are ideal for different kinds of construction. Sand mined here is transported to nearby cities like Indore, which is among the biggest cities in the country. The

excavated sand is also transported across state borders to neighboring Maharashtra, a state which has the highest GDP in India, an indicator of development (PRS Legislative Research 2018). It was pointed out that the absence of new incoming sand for the last four years has worsened the problem. Hinting towards the minimal water discharge in the river from several dam projects on the Narmada river which have repeatedly faced criticisms from locals as well as civil society accusing the state of destroying local biodiversity, culture, and economy in the name of development (Bose 2004).

As a result, the water for irrigation of nearby agricultural land is almost entirely depleted because of which landowners are resorting to groundwater extraction using wells and boring. He also tells me that the economy of six nearby villages is dependent on illegal sand mining since most people in these villages are not landowners and depend on external seasonal employment and illegal sand mining. The only viable option for a stable income is to mine illegally, which guarantees stable employment throughout the year.

The conversation also revealed that the sand mining hotspots have also become a place for social activity in these villages since a vast majority of populations of surrounding villages spend a large part of their time at the riverbanks as mining goes on 24 hours. Regular and full-time miners have made makeshift shelters to take rest in between their breaks on the banks in proximity to the mine so they don't waste time and can maximize their income by eating and sleeping nearby. This has also led several kinds of small informal businesses to have to pop up around the mines to cater the services to the laborers who have practically started living there. These ventures include vegetable sellers, snack vendors, tobacco vendors, as well as alcohol shops.

The sand mining mafia has also shifted the mining techniques and has procured heavy machinery to mine instead of using manual laborers as it's getting more difficult to mine on the

river banks because of depleting sand and it's much more efficient to use than manual labors when it comes to river bed mining. The interviews further revealed that the Panchayat (Village Council) officials and local administration are also directly involved in illegal sand mining. Several people in the village and block administration own the trolleys which are intended to use with tractors for agricultural purposes and in some cases, they own dumper trucks which are solely intended to transport construction material like sand, gravel, and cement. According to interviews, which were authenticated, approximately 250 trolleys are available in the village. This is the case with every village nearby with an average population of 2500. Among which 90% of the households own one or more tractors, which is significantly higher than both the regional or national average. The tractor- trolley combination is preferred not only because it is the cheaper alternative to dumper trucks but also because in case of raid or police bust, it's easier to detach the trolley and maneuver the tractors to a safe distance and blending in with other agricultural machinery. When asked about the issue with the village officials, they claimed the tractors and the trolleys are solely for agricultural and allied activities. And yet the agricultural conditions in the vicinity paint a different picture, a consistent decline in production every year.

Visual observations, as well as the interview with former miners, confirm that the children from below the age of 14 and sometimes as low as the age of eight are involved in the loading of the trucks, which are often done manually since heavy machinery cannot go down to the river. Children take less money and easier to control for the sand mafia henchmen overseeing the mining operations. Children are also handy at the mines to empty the trucks faster and run errands for the miners.

The village populations are approximately 2000 to 3000. And it was verified that there are only a handful of college graduates between the ages 25 to 35 and haven't been able to find a job,

which is why they are resorting to mining. It is pertinent to note that every male member and oftentimes female members of almost all the families from the age of eight to sixty-five are in one way or another involved in illegal sand mining, whether it's loading, digging or auxiliary services.

It was observed that Bharatiya Majdoor Sangh (BMS) which is one of the trade union of a leading political party in India, has issued employee ID cards to labors involved in illegal mining. The BMS has been known for paying the miners allowances and bonuses and along with compensation to the victims of accident involved in sand mining. It is pertinent to note that the ID cards which are issued are not regulated or legal since the labors are involved in illegal activity.

It was also discovered that due to lack of public transport system in the region, people often use the dumpers and trolleys used to transport sand as a public transportation system. They pay the drivers of these vehicles to hitch a ride from one village to another, and to nearby major cities where the sand is being transported to. This has further led to a decline in the already weakened privately owned transportation system in the region, as people opt for the cheaper alternative, which are mining vehicles forcing the bus operators to reduce the number of trips.

Farmers whose land is connected to the rivers or the ones whose land is used as the way to reach the river charge money for every vehicle which is used for mining to pass through their land as an easement or convenience charge. These charges can depend from Rs.100 (USD 1.4 approx.) per vehicle to up to Rs.500 (USD 7.3 approx.) per vehicle. On an average based on the observations, around 120 vehicles were going through in one of the mining hotspots in just one day. The observation confirmed that most of the vehicles were trolleys and not trucks. Tractors were making multiple trips from the basin to the dump sites with different trolleys. Later upon probing further, it was revealed that these trolleys take the sand to local dumps

where they are reloaded in bigger trucks and are transported to the bigger cities. Oftentimes, these dumps are given directly to the construction companies or just sold to the first customer, which they find on the way.

Discussing the law enforcement mechanisms, it was revealed that corruption easily removes that obstacle for the miners. Every police station has a fixed monthly allowance of 2000 rupees (USD 30 approx.) each for every vehicle used for mining to allow operations. Further, a fee of 500 rupees (USD 8 approx.) are to be paid by the vehicles carrying sand at every checkpoint they pass; these checkpoints can be operated by different state government departments, i.e., Police Department, Mining Department, and Revenue Department.

Even though most locals are aware of the environmental visibly, disturbing environmental consequences, yet they do not choose to change their course of action. This is because of the lack of availability of any other alleviating alternative. This is pushing the community towards generational poverty due to the rise of this parallel regional economy, making sustainable development in the region impossible.

The ripple effect of this phenomena is not only limited to the economic development of the region but also is affecting the education and health of the region which in turn is limiting the employability of the population in the region. The trickle-down effect of the mafia is that the corporations are unwilling to invest in the region because of a potential clash with the powerful mafia controlling the region with everyone in their pockets or at the end of the barrels of their guns.

2.4 Stages

The mining operations have four essential stages: extraction, loading, transportation, and, storage/sale. These stages are interlinked to one another and have variations depending upon

the geography, availability of equipment and labor, distance to destination, and the political climate (Rege 2016).

2.4.1 Extraction

Sand is mined on the river banks and from the riverbeds using excavators and drillers whenever the geography and the local political climate is agreeable. Otherwise, it is common to employ labors using hand tools for the river banks and divers paired up with fishermen on a small iron boat often with custom motorized pulleys to pull buckets of sand from the water. Excavation does not necessarily require any technology or skill and can be done using shovels and wheelbarrows, which are already available with the local farming community. Mining takes place 24 hours of the day, often picking up speed at night to avoid detection (Shrivastava et al. 2015). Top of the line expensive machinery is used, which is funded by the mafia in exchange for set minimum quantity mined every day. Machinery from mining corporations and well as construction companies are also used depending upon their agreement with the mafia regarding the supply. Extraction from the river beds has now deepened the river beds from 40 to 100 feet leading to deep diving by miners, which often proves fatal (Srivastava 2017).

2.4.2 Loading

The time of loading is crucial for illegal sand mining, during this time, the mobility is restricted, and the chances of getting caught by the authorities are high. In most cases, trolleys as well trucks get filled by excavators on the banks and take them to storage nearby, but in some cases, trucks take turns to get filled by excavators and then transport it to the distributors. But with time, the loading process has evolved. Since the river basin has gone down due to excavation, it is getting increasingly difficult for trucks to climb back up after carrying the load of sand. Therefore, dump and load sites are created on top of basins to make the operation more efficient. The trolleys are used to dump the sand on these dump sites where they are quickly

and efficiently loaded onto the trucks for long route transports and to other trolleys for shorter distances. Almost all the trucks are illegally modified to carry over the limit sand of about 2.5 tons. This gives the miners the added advantage of increased mobility by breaking up the operation into two parts.

2.4.3 Transport

Transporting the illegally mined sand requires extra care because the possibility of getting caught while transporting it has a bigger consequence since the vehicles used for such transport can be impounded. Trucks, trolleys, and boats are used to transport sand. Temporary "kutcha" roads and temporary pontoon bridges are often laid out to transport the sand. This is done to bypass the checkpoints on roads and bridges, allowing for an uninterrupted and unchecked operation (Shrivastava et al. 2015). Boats are used for short distance transportation as well as to avoid the checkpoints on the roads. On the roads, mafia henchmen patrol the fixed route of their vehicles which enables them to not only alert the drivers of vehicles carrying the sand about possible raids and checkpoints of the authorities but also to delay the officials from carrying out their duty (Rege 2016). Another externality to this process is the increase in accidents on the roads used by these vehicles. Since the drivers are paid for each trip they do from the mine to the dump site, they are indirectly incentivized to rash driving which often proves fatal to the other users of the roads (Mitra 2018; NDTV 2019).

2.4.4 Storage and Sale

Following the excavation, the sand is either directly sent to the construction site or to a transit point. Both of which are at a short distance, transit points serve as storage and holding area. Houses owned by the mafia or by locals paid by the mafia are used as these storage spaces. Sand is often stored for a long period of time and is sold when the demand is high, particularly during monsoon season and can be sold up to three times the normal price. Similarly, locals

who mine themselves also store sand in their houses also sell to either the mafia or directly to the customers depending upon the demand having converted farmland into storage spaces, instead of using it for agricultural purposes. This stage is interlinked with the last stage of transportation, and therefore, the transportation of the sand depends on the destination of the sand. This stage is also dependent on the geography, arrangement with the mafia, construction activities, and the location of buyers.

2.5 Laws and Regulations

In most developing countries, including India, the regulatory mechanisms concerned with mining and dredging are put in place without taking into consideration the scientific and environmental consequences (Maya et al. 2012). The Mineral Resources Department of the Government of Madhya Pradesh introduced a Mineral Policy in 2010 which does not talk about Sand mining and focuses on other minerals available in the state. The department then released a new policy on sand mining in 2015 and 2017 respectively under the Madhya Pradesh Minor Mineral Rules, 1996. The policy merely talks about identification of mining quarries in the state and the auctioning and award procedure of sand mining in the state with the purpose of ensuring access to sand in the state for development purposes, while not harming the environment with mere mention of illegal sand mining without acknowledging the problem and thereby without a need for solution (Mineral Resources Department 2018).

Following the criticisms of the absence of illegal sand mining in the policies, the Government released a new policy through state gazette as Madhya Pradesh Sand Mining Rule, 2018 discussing several sand mining issues at length. The rules address the apparent concerns regarding sand mining in the state and provides guidelines for identification of quarries, allotment, permits, storage and transport along with the restrictions which were missing in all previous policies and therefore supersedes all previous policies while repealing Madhya

Pradesh Minor Mineral Rule, 1996 and Madhya Pradesh (Prevention of Illegal Mining, Transportation and Storage) Rules, 2006. Chapter VI of the rules deals specifically with illegal mining of the sand and its investigation while breaking down the penalties for unauthorized mining and storage (Mineral Resources Department 2018).

This document is also exhibiting the debut of the government's proposal to use technological tools for monitoring and evaluation of sand mining operations. The rules prohibit the entry of a vehicle in stockyard and quarry without a G.P.S monitor onboard (Mineral Resources Department 2018). This document, however, does not specify details about the monitoring system and leaves it open if the Mining Department or Madhya Pradesh State Mining Corporation is entrusted with monitoring this technology. The permits are issued by the Mining Department, and the licenses are issued by the Revenue Department, which further leads to confusion of jurisdiction and oversight.

In 2015, The Mines and Minerals (Development and Regulation) Act of central government, created a provision for the state governments to prescribe the contribution amount to be paid by concession holders of minor minerals to the District Mineral Foundation - a mechanism created to help community development in the vicinity of a mining area (Ministry of Law and Justice 2015). The Comptroller and Auditor General of India (CAG) in January 2019 indicted the Mineral Resource Department of the State of Madhya Pradesh for a "half-hearted implementation" of the act (Upadhyaya 2019).

CHAPTER 3 – TECHNOLOGIES AND RECOMMENDATIONS

3.1. Technological Solutions

The vacuum created by the absence of monitoring of sand mining and extraction has contributed to a gap in knowledge which has, in turn, led to a lack of action. Inability to obtain information regarding the adverse effects and cost of sand mining with weak governance and unchecked corruption are facilitating illegal sand mining. The government relies on a system which has several gaps in linkages in the monitoring of the mining operations. Several technologies can be used to tackle this issue of sand governance.

3.1.1 Blockchain

Researchers have developed a business framework model by applying the blockchain technology to provide a distributed concurrency monitoring system for supply management of sand. Applying blockchain technology can provide new opportunities for enhanced transparency and increased engagement in sand mining and its supply chain. Agent-based modeling and simulation system has proven to be an effective tool which employs a bottom-up approach for monitoring illegal sand mining (Pour, Tatar, and Gheorghe 2018). Blockchain allows the actors in any system to transact digital assents using peer-to-peer network that stores these transactions in a distributed way across the network through distributed ledger technology for information sharing (Ølnes, Ubacht, and Janssen 2017). The proposed model proves that employment of blockchain technology provides technical, economic, and strategic benefits all the while leaving a reduced footprint on the environment. The model is also promising to improve the sustainability of sand supply over time while improving the governance of the sand resources.

The sand miners with permits and users are modeled as a collection of autonomous decision-making entities known as agents and these agents interact with each other where regulators participate in making decisions as intermediaries based on a set of rules that are defined within the blockchain network (Pour, Tatar, and Gheorghe 2018). The government agent acts as the regulator that reviews and monitors the operational conditions. A recent study on agriculture on implementation of blockchain technology for agriculture in Madhya Pradesh concluded that infrastructure and tools to implement blockchain technology already exists, and willingness of stakeholders for multi-stakeholder partnership is needed to implement this technology successfully (Dubey 2018).

3.1.2 Geospatial Mapping

The ability quantifies the extent of mining spatially is a critical component and is vital for monitoring and decision making. The information related to mining has some sort of spatial component which can be represented in map form, which helps in providing important contextual and background information. Realizing the importance of Geographic Information System (GIS) technology, management, and mineral economists are now using GIS in their evaluation of assets to consolidate and aggregate information and to make more accurate business decisions (ESRI 2018). Geospatial Mapping helps in mining governance in several ways: Evaluation of mining conditions, monitoring of hydrological data, application of mining permits, assessment of environmental impact, land title management, management and policing; all these solutions can be benefitted from by merely deploying the GIS technology.

There is a precedent of using Geospatial Mapping in mining in several cases around the world. Bellingcat, an open source investigative journalism website, used geospatial analysis to monitor a gold mine project in Armenia. The project used the satellite images to assess the environmental impacts of the mining in the region, the publication of the analysis led to a public

movement which resulted in a halt of construction activities at the mines (Khachatryan 2017). Similarly, research has shown that GIS-based modeling can help in not only monitoring of mining activities but also in the assessment of the negative externalities coming out of mining, such as its impacts on soil, water, forest and agricultural activities (Hoffman 2007; Suh et al. 2017). Indian Space Research Organization (ISRO) has also proposed using their satellites to help curb illegal sand mining using geospatial mapping (Singh 2018).

3.1.3 Electronic Bill of Lading and Mining Permits

The mining permits and bill of lading are issued by the mining department through an online system but are provided as printed copies to the vehicles carrying sand. The problem is that paper bills are easy to forge (Gobrecht 2011). The details of these documents can be changed very easily; it is safe to say that without proper documentation, fraud will remain rampant. A simple solution to this is the issuance of electronic permits which are publicly available online using the barcode or the transaction number which can be scanned by the smartphone cameras and crosschecked with the publicly available database through an app-based system creating a transparent, accountable and convenient system for any government department to use in fulfilling their duties.

3.1.4 Enterprise Resource Planning

Enterprise Resource Planning (ERP) is using integrated management in real time using the Internet of Things (IoT). IoT is a concept that defines the interconnection of devices and technologies through the internet, acting together in harmony. Simple technologies in isolation might not be as effective as they are when they work together towards one purpose. ERP facilitates information flow between all activities and manages connections to outside stakeholders, in this case, connecting the devices on a unified platform using integrated applications which the regulatory bodies can use to collect, store, manage, and interpret data

from different mining activities could prove to be a cost-effective, easy to implement and quantifiable solution for sand governance (Hayman 2000).

A combination of technologies which are already in use is a viable solution to implement. These include the Global Positioning System (GPS), Smartphones, QR Codes (Ray, Mukherjee, and Shu 2017). The regulation already makes it mandatory for the trucks used for transport at the mining location to have a GPS unit installed, yet monitoring mechanism is nonexistent. Creating a single platform with all the GPS data of every trip made by the truck will allow for more transparent monitoring. Retrofitting a unique QR Code to every vehicle used and associating it with the GPS unit attached the vehicle with electronic permits for mining will make it extremely efficient to monitor the supply of sand thereby giving back the control to the authorities under transparency. Unmanned Aerial Vehicles (UAVs)/Drones equipped with night vision cameras have also been proposed to carry out surveillance and monitor mining operations with an intention to deploy human operated drones and later operated by Artificial Intelligence (AI) in harmony with the ERP system (Indian Express 2019; Mohamed Imranullah S 2019). This unified platform can be fed information with smartphones owned by miners, the vehicle drivers and, relevant authorities. This is easy to implement given the fact that the smartphone penetration in India and in this region is quite high (Bhattacharya 2018). The government is increasingly relying on smartphone-based telecommunication infrastructure to implement policies in the education and healthcare sector (Jagran Josh 2015).

3.2 Recommendations

Addressing the problem requires improving the monitoring systems, better regulatory policies, and impact assessments on the environment. Based on the observations and the loopholes in the policy, the policy intervention, which can be most effective is at the supply side and in loading, transportation, and sale stages.

One way to tackle this problem is by creating and incentivizing alternatives to sand consumption while optimizing the use of existing buildings and infrastructure through tax breaks and nudging through regulatory mechanisms. Quarry dust and recycled building material acts as a suitable substitute for sand in construction and therefore should be incentivized and promoted starting with government tender specifications (Khamput 2006). Further, glass recycling plants should be established to reclaim the sand as grinded glass is a perfect substitute for sand not only for construction but also to restore environmental damage. Desert sand can also be used for construction purposes when mixed with other materials with minimal processing (Zhang et al. 2006).

Sand, even after being heavily extracted, remains the cheaper alternative which is freely accessible with its primary cost being extraction and transportation, thereby leaving no incentive to stimulate a change in the demand. Alternative sources of sand like the sand stuck behind dam walls can be targeted, solving multiple problems at the same time i.e. of fulfilling the demand of sand, increasing the dams' water holding capacity and restoring aquatic balance in rivers' ecosystems all the while reducing the negative consequences of extraction (Ashraf et al. 2011).

The technologies examined above are the viable choice for this case based on the literature available, discussions, and their feasibility. It is pertinent to note that these technologies in seclusion will only deal with one aspect of the problem. Therefore, a combination of the above-exhibited technologies can be employed for the most efficient outcome, i.e. Decline in sand mining.

CONCLUSION

Sand is the most used resource by volume after water and the demand dramatically exceeds the renewal rates of sand, and yet the mining has increased significantly primarily due to rapid economic expansion in developing countries, particularly in Asia (Alexander et al. 2011). The ease of availability, unrecognized importance and lack of awareness on the issue has further contributed to the rise of the problem of extraction.

The problem has reached to the extent that the river ecosystems are being destroyed at numerous locations with unequivocal damage to smaller tributaries (Kondolf 1997). And yet a large gap of unawareness in public persists with regards to the magnitude of the problem leading to inaction. The ease of availability, unrecognized importance and lack of awareness on the issue has further contributed to the rise of the problem of extraction. It is critical that essential initial steps are taken to ensure the problem from blowing out of proportions. Following which careful research and data analysis, updating of regulatory framework and implementations of policy interventions are needed.

The proposed solutions are designed in such a way that they channel the innovative technologies towards increasing human engagement and transparency, all the while ensuring a healthy climate for businesses and unhindered and yet sustainable development that will impact generations to come. The focus is towards reducing the demand for sand without threatening the economic development in the region; i.e. a move towards sustainable development.

The observations exhibit the underlying causes of the problem as well as the loopholes in the current policy, which is being exploited by the sand mafia and the locals in the region. The collaborations of multiple stakeholders from across the spectrum, including the locals, mafia, corporations, and officials, are not only unique but also dangerous for the environment and the

people in the long term. The observations affirmed that stakeholders indulge in illegal sand mining for short term and easy monetary gains without realizing the long-term consequences of their activities. Some of these consequences are already starting to take shape like the effect on agriculture due to the change in water flow while other consequences are metamorphosing slowly into generational poverty due to the domino effect of bad decisions by the current generation.

The analysis shows that technologies can help curb if not eliminate illegal mining in the region and do not require an administrative overhaul of extensive resources. The deployment is resourceful and economical while the monitoring is transparent and efficient, making it a viable solution for the problem at hand.

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APPENDIX

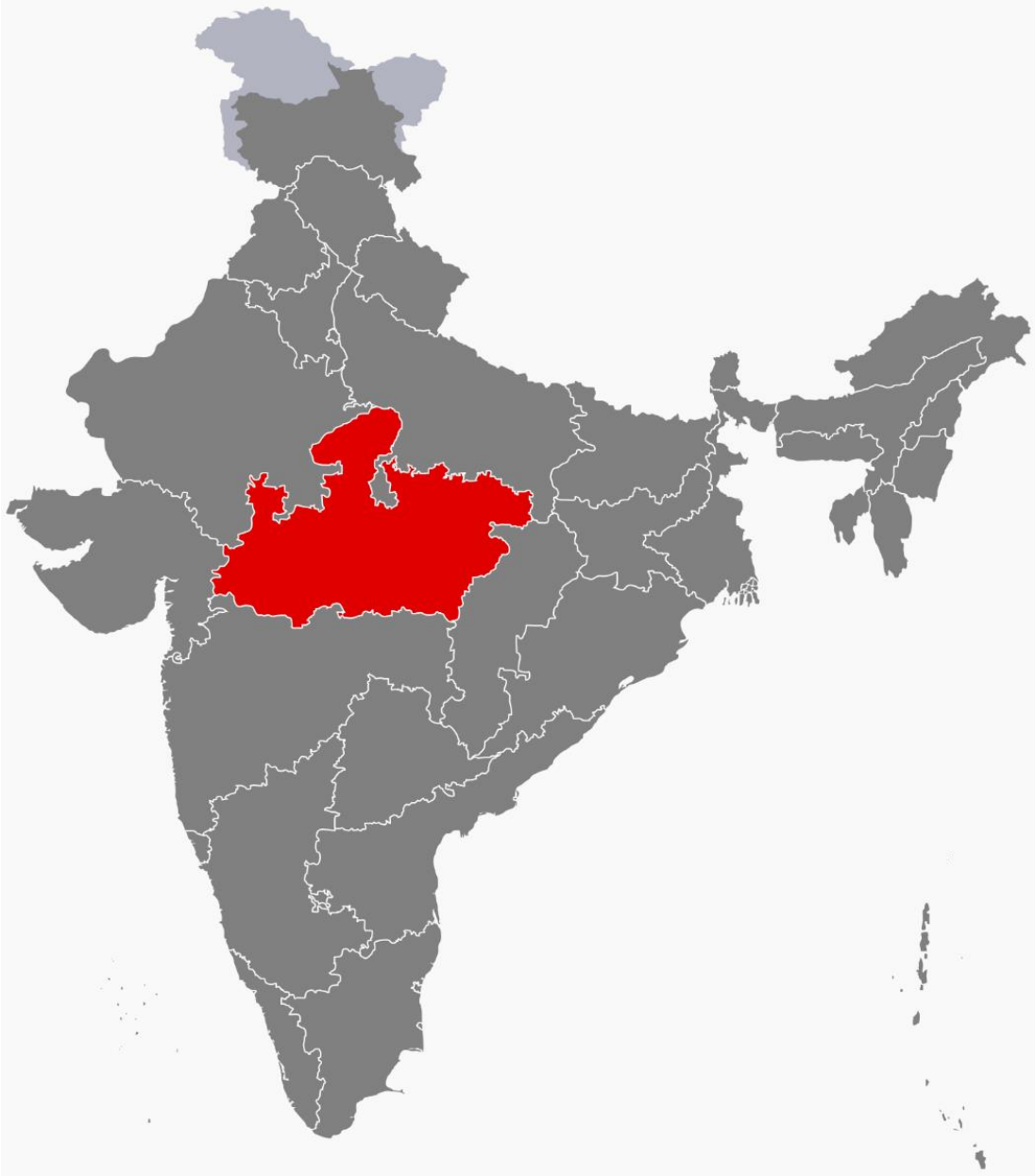

Figure 1- State of Madhya Pradesh within India highlighted in red (Source: Wikimapia)

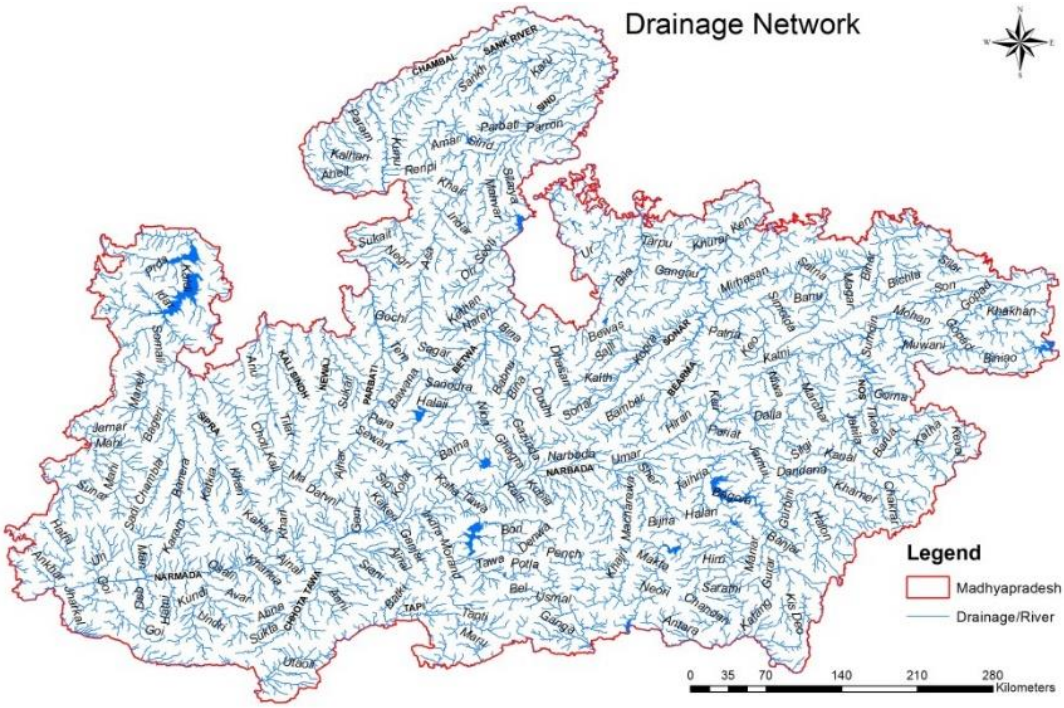

Figure 2 - River basins and their drainage in Madhya Pradesh (Source: SANDRP)

Figure 3 - Narmada River and it's tributaries (Source: International Rivers Network through the University of Michigan at http://umich.edu/~snre492/Jones/narmada.html)

Satellite images of Maroda Sand Mine. Hoshangabad District, Madhya Pradesh which is one of the biggest Sand Mining hotspots in the state. The change in river course and displacement of sand is clearly visible.

Figure 4- Images from a timeline generated of the mining hotspot on open source map. (Source: Planet Labs at https://www.planet.com/stories/maroda-sand-mine-LLM0CN7ZR)

Figure 5 - Narmada and Tawa Rivers around Maroda June 2009
(Source: NASA Worldview at https://worldview.earthdata.nasa.gov/)

Figure 6 - Narmada and Tawa Rivers around Maroda June 2019.
(Source: NASA Worldview at https://worldview.earthdata.nasa.gov/)