



Construction Raw Materials in India and Indonesia

Market Study and Potential
Analysis | Preliminary Report

July 2020



Imprint

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ABOUT THIS REPORT

This report presents the preliminary desk-based research conducted for the study on construction raw material value chains in two metropolitan areas in India and Indonesia.

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Jörg Böhling / visualindia.de – Hard working woman at a granite stone quarry in India.

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Acronyms

ASM	Artisanal and small-scale mining
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
C&D waste	Construction and demolition waste
DGMC	Directorate General of Minerals and Coal
ECBC	Energy Conservation Building Code
EIA	Environmental Impact Assessments
EPA	Environment Protection (Amendment) Act
FCA	Forest Conservation Act
FSI	Floor Space Index
GDP	Gross domestic product
GRIHA	Green Rating for Integrated Habitat Assessment
IBM	Indian Bureau of Mines
LPJK	National Construction Services Development Board
LSM	Large-scale mining
MEMR	Ministry of Energy and Mineral Resources
MoEFCC	Ministry of Environment, Forest and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MMDR	Mines and Minerals (Development and Regulation)
MoMSME	Ministry of Micro, Small & Medium Enterprises
M-sand	Manufactured sand
NBCI	National Building Code of India
NCT	National Capital Territory of Delhi
NCR	National Capital Region of Delhi
NGT	National Green Tribunal
OBC	Other backward castes
OHS	Occupational health and safety
PEPs	Politically exposed person
PPE	Personal protective equipment
SC	Supreme Court of India
SCST	Scheduled casts and scheduled tribes
SIPB	Rock Mining Permit

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1. Introduction

Industrial minerals and construction materials make up 84% of mineral production across the globe. The price and value of most construction materials on global markets is comparatively low, exports are limited, and foreign direct investment is low. This is why not much attention has been paid to these materials. However, as they are typically used in the region or country they are produced in, for example in construction, manufacturing, or agriculture, they have the potential to significantly contribute to the local economy and poverty reduction. The quarrying and mining of construction materials provides many low-skilled jobs. Next to the positive effects for the local economy, the construction materials sector is prone to risks due to its widely informal character. This includes health and safety risks, child labour, and adverse environmental impacts (Franks 2020; Hilson 2016). Also the greenhouse gas (GHG) impact related to the construction raw materials sector is significant. Over 50% of GHG emissions are related to materials management, and that will further rise in the next decades (OECD 2018).

The importance of non-metallic minerals is going to increase in the coming decades. The OECD estimates that global materials use is projected to more than double between 2011 and 2060, from 79Gt to 167Gt. Non-metallic minerals represent around half of that. Their use is projected to rise from 35Gt in 2011 to 82Gt in 2060. In India, the infrastructure boom is already coming to an end, but nonetheless materials use in the country is projected to grow from 6Gt in 2011 to 23Gt in 2060, accompanying economic growth (OECD 2018).

The construction industry is the largest consumer of raw materials globally (World Economic Forum (WEF) and The Boston Consulting Group 2016), consuming around 3000Mt per year, which is around 50% of the total by weight (Pacheco-Torgal and Labrincha 2013). Constructed objects account for 25–40% of total global carbon emissions. There are trends of transitioning towards a low-carbon construction industry (IFC and CPLC 2018). The OECD projects recycling of materi-

als to become more competitive in comparison to the extraction of primary materials, due to technological developments and changes of the relative prices of production inputs (OECD 2018).

Construction consists mainly of residential housing (38%), transport, energy, and water infrastructure (32%), institutional and commercial buildings (18%), and industrial sites (13%). In developing countries, the construction industry can account for more than 8% of GDP (v. 5% in developed countries). Currently, more than 100 million people are working in construction around the world. The industry is expected to undergo significant growth in the coming years (World Economic Forum (WEF) and The Boston Consulting Group 2016). The projected growth between 2018 and 2023 was 4.2% per year. Urbanisation and population growth drive this increase, with an estimate of 75% of the infrastructure that will be in place in 2050 still having to be built (IFC and CPLC 2018).

Not only demographic changes are a megatrend that needs to be observed in order to understand changes in the construction value chain. Other factors are the availability of energy, digital and technological developments and climate change mitigation (De Groote and Lefever 2016).

Considering the growing importance of construction raw materials and industrial minerals in the economy, their environmental and social impacts, and their potential to contribute to local development and poverty reduction, the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) commissioned this study under the title ‘raw materials construct metropolises’. Its objectives are to gain a better understanding of the market barriers, opportunities, and potentials of locally produced construction raw materials in the metropolitan areas of New Delhi, India, and Surabaya, Indonesia. The focus lies on urban areas and their surroundings (with a radius of around 100–150 km) because construction raw materials are typically high volume and low value and therefore mostly extract-

ed close to the locations of processing, manufacturing, and construction. The study aims at understanding and analysing the construction material value chains, including aspects such as current conditions and impacts of extraction and recycling, processing, and manufacturing as well as transport, and analysing obstacles and the potential for greater local value addition for local development, as well as the climate change impact of those value chains. The focus of the study lies on sand and gravel, crushed rock, dimension stone, slate, carbonate rocks, gypsum and anhydrite, clays, lightweight aggregates, silica raw materials, glass, and cement.

The preliminary report, which the final report will build on, is based on desk-based research and remote interviews. It uses statistical data, secondary literature, and existing reports to build a basic understanding of the construction raw material value chains in India and Indonesia, with a specific focus on New Delhi and Surabaya. Remote interviews were conducted in both countries to complement the literature review:

INDIA - INTERVIEWEES	INDONESIA - INTERVIEWEES
Prof. Abdul Baqi, Professor, Aligarh Muslim University.	Arsam Sunaryo, Director of CV Asri Keramik Bandung.
Anjan Mitra, Practicing Architect & Urban Designer. The Appropriate Alternative. School of Planning and Architecture.	Ministry of Trade: Iman Kusitaman, Chief of the Oil & Gas and Mining Division; Berlin Kusuma Wardani, Chief of the Mining Product Section; Devi Avianto, member of staff.
Arunava Dasgupta, Associate Professor of Urban Design, School of Planning and Architecture.	Dra Endang Pratiwi MM, Head of Sub Directorate of Planning, Policy and Mitigation Tools, Directorate General of Climate Change Control, Ministry of Environment and Forestry (KLHK).
Geological Survey of India – Name withheld.	Farid Muhammad, Chief of Environmental Monitoring and Follow-up Section, Directorate General of Prevention of Environmental Impacts of Business Activities, Ministry of Environment and Forestry (KLHK).
Dr. Gurdeep Singh, Founder member of the Centre of Mining Environment (CME) and Department of Environmental Science & Engineering (ESE) at Indian School of Mines, Indian Institute of Technology, Dhanbad.	Abdul Madjid & Fitri, Non-agro Division, Trade and Industry Agency, East Java.
Kuntala Lahiri-Dutt, Professor, Resource, Environment and Development (RE&D) Program, Australian National University.	
Nandita Talukdar, Manager - Resource mobilization and M&E, CREDAI.	
Pradip Chopra, Former Governing Board Member, CREDAI, Chairman, PS Group.	
Prem Mahadevan, Senior Analyst Global Initiative Against Transnational Organised Crime. Author of: Sand mafias in India: Disorganized crime in a growing economy.	
Thangaperumal Ponpandi, Country Manager India, Terre des Hommes Netherlands.	
Sanjay Seth, Senior Director of the Sustainable Habitat Division; Megha Behal, Associate Fellow; Ankita Bokhad, Research Fellow. The Energy and Resources Institute.	
Vikash Nayak, Construction sector consultant.	

The research results are limited and compromised by a number of factors. The construction raw material sector is still understudied, despite growing recognition of its importance in local economies. The material available was therefore limited, and many research gaps remain, which can only be filled by field research. Another limitation was the ongoing Covid-19 crisis, which has led to strict lockdowns in India and Indonesia, limiting the access to interview partners and data and reports that are not publicly available. The preliminary report therefore should be considered as laying the groundwork for the field research phase. Its shortcomings will be addressed during that phase, which will seek to close the gaps mentioned in this report.

The report starts with a short country overview of India and Indonesia and the selected metropolitan areas.

The subsequent market study has three sub-chapters: first it provides an overview of the materials selected by BGR for the study, in terms of their composition, extraction, processing and use in construction, laying the ground for the country- and city-specific sections. Second, using the example of five selected materials for India and five for Indonesia, the chapter will examine the local value chains, from extraction or recycling to processing, manufacturing, transport, and trading to the use in the construction sector. It will look at the current situation, processes and actors, social and environmental impacts, and climate change impacts and mitigating measures. Third, a first assessment of market barriers and opportunities will be provided. The potential analysis will be completed after the field research. Finally, research gaps will be lined out, followed by a draft plan for the field work phase of the project.

2. Country overview

2.1. India

As per the U.N. World Urbanization Prospects 2018 report, about 34% of India's population lives in urban areas,¹ an increase of about 3% since the 2011 Census. (The Hindu 2018). In fact Delhi has been experiencing one of the fastest urban expansions in the world making it the world's second most populous urban agglomeration with a predicted population of 37.2 million people by 2028 (Economic Times 2019). The reason for such rapid urbanization is Delhi's per capita income that is the highest in India, attracting large numbers of migrants (Earth observatory 2018). To accommodate this unrestricted inflow, Delhi has been compelled to expand to its neighbouring regions and be divided into zones – National Capital Territory (NCT) of Delhi, Central National Capital Region plus NCT and National Capital Region (NCR) (Fig. 1). These three zones are all inter-dependent and integrated in their development plan.

Although, Delhi has a unique problem of low Floor Space Index (FSI) ratio, meaning that the potential for vertical development is limited (Housing 2018), Delhi's housing and infrastructure development sector has been seeing an exponential growth in budget allocation by the Government (33.49% from 2018 – 19 to 2019 – 2020), reaching 460 mio. Euro in 2019 – 2020, with half of it being proposed for development works in informal settlements (Realty, 2019). A budget used to create urban infrastructure such as water supply and sewerage facility, provide affordable housing and increase the availability of low cost 'pucca' houses for the poor and lower-middle class people, develop the road infrastructure as well as develop group housing societies and regularise unauthorized colonies (ET Realty 2019). New Delhi has retained its position as a prime residential market among top global cities (Hindustan Times 2019).

At the country level the real estate segment accounts for about half of the construction sector while the oth-

er half is infrastructure. This unprecedented growth has been fuelled by the relaxation given in building norms (floor area ratio, number of storeys) as a result of the promulgation of Master Plan of Delhi-2021. And while domestic production has so far been capable of catering to the needs of the sector, a small but slowly growing trend of imports of certain construction materials (limestone and gypsum most notably) has recently started and is in line with the growing potential raw material shortages faced by the sector (GIZ 2016), in particular for gypsum (Times of India 2020a) and sand (National Geographic 2019).

India's mineral resources management framework classifies minerals into two different groups. Major minerals are managed by the Federal Government and its agencies, a list that includes all metallic and energy minerals, as well as diamonds and minerals with key industrial applications such as graphite, fluorite, perlite or asbestos. Minor minerals are owned by the State in which they are located, and the States have authority over their regulation, administration, licensing, exploration, mining, and taxation. A major re-organisation of mineral classification took place in 2015 with the promulgation of the Mines and Minerals (Development and Regulation) Amendment Act (MMDR) 2015 and 31 erstwhile major minerals have been classified as minor minerals, thus expanding it to now include all construction minerals with no further industrial uses. And while all states have a central agency in charge of managing mineral resources, such as a Ministry of Mines or Directorate of Geology most of the day to day administration of minor minerals takes place at the district level². A notable exception is Delhi NCT where no single authority responsible for mineral resources could be identified,³ despite sand extraction taking place within the confines of NCT⁴.

¹ A figure that does not include the semi-urban sprawls located in proximity to the metropolises (interview with Prem Mahadevan).

² Districts are sub-division of each State and are in turn composed by a varying number of sub-districts.

³ Based on research, document consultation and stakeholder interviews.

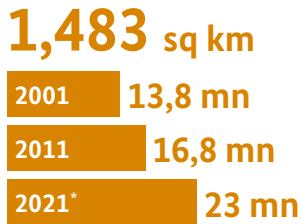
⁴ Interview with Dr. Gurdeep Singh.

Figure 1 – Delhi’s population trends

Rising population

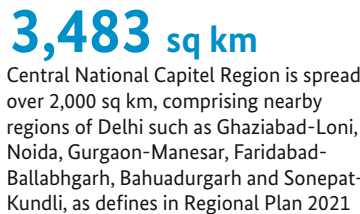
How the population of Delhi, Central NCR and NCR has grown in the past 20 years

National Capital Territory (NCT) of Delhi



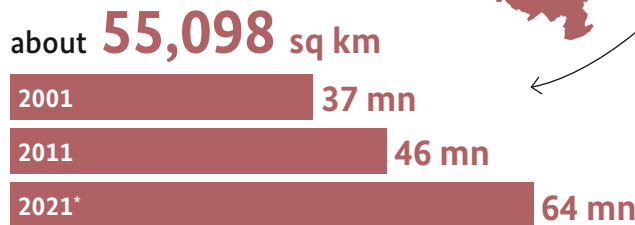
* Projection

Central National Capital Region plus NCT



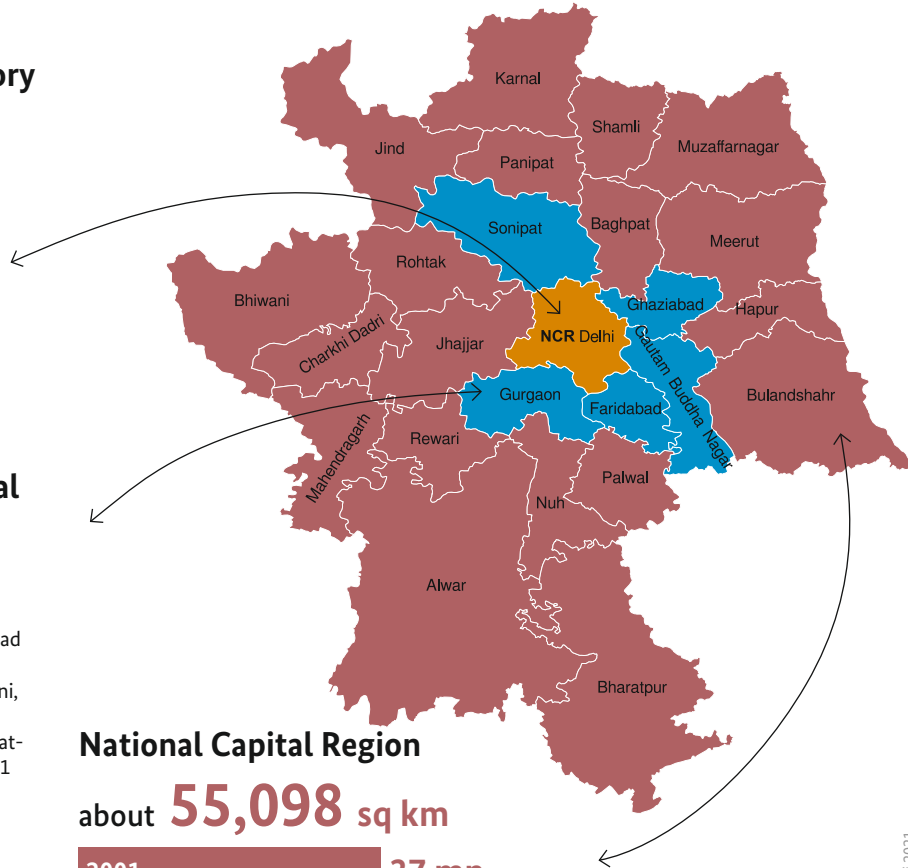
*2021 projection is not available

National Capital Region



*Projection

NCR includes Baghpat, Bulandshahr, Gautam nBuddh Nagar, Ghaziabad, Hapur, Meerut, Muzaffarnagar, Shamil, Bhiwani, Faridabad, Gurgaon, Me-wat, Jhajjar, Jind, Karnal, Mahendragarh, Palwal, Panipat, Rewari, Rohtak, Sonipat, Alwar, Bharatpur



Source: Census Reports, Master Plan Delhi 2021

As a result, the applicable legal framework is dependent on the states where extraction, transport, trade, and processing take place; creating a number of governance issues and challenges described in subsequent sections. Nevertheless, several country-wide regulations or mechanisms apply to the mining sector. Chief among them are:

For environmental aspects (ICC and CUTS 2018)

- ▶ The Forest (Conservation) Act (FCA 1980), amended in 2014, empowers the Central Government to take all measures deemed necessary to protect the

environment, and prevent, control, and abate pollution. Its administration is part of the responsibilities of the Ministry of Environment, Forest and Climate Change (MoEFCC).

- ▶ The Environment Protection (Amendment) Act (EPA 2006) lays down the requirements of the Environmental Impact Assessments (EIA) required for project approval by MoEFCC when required, most notably this applies when mining would take place on forested land in which case MoEFCC approval is required even for minor minerals extraction.

- ▶ EIA Guidelines are currently being revised, and according to environmental stakeholders are being watered down (Times of India 2020).
- ▶ The National Green Tribunal (NGT) is a federal special tribunal established to handle environmental issues.

For labour and social issues (ICN, SCL, Glocal 2017)

- ▶ The Mines Act, 1952, as well as the Child Labour (Prohibition and Regulation) Amendment Act, 2016, prohibit the employment of children under 18 years in mining operations.
- ▶ The Industrial Establishments Act requires businesses employing ten or more workers at any time to provide formal employment contracts.
- ▶ The Contract Labour Regulation and Abolition Act, 1970, protects contract labourers. The act makes a number of provisions for the welfare of contract workers including payment of minimum wage, social security benefits and others. The government can also decide to prohibit the use of contract labour to perform core activities of the enterprise of perennial nature.
- ▶ The Inter-State Migrant Workmen Act, 1979, prescribes that companies need government documentation and approval to employ migrant workers. The Act encompasses issues relating to the payment of travel and the provision of suitable residential accommodation for migrant workers.
- ▶ The Minimum Wages Act, 1948, in India guarantees the payment of minimum wages to workers in various sectors, including the mining sector.
- ▶ The Bonded Labour Abolition Act, 1976, prohibits the practice of bonded labour. This Act frees all bonded labourers, cancels any outstanding debts against them, prohibits the creation of new bondage agreements, and orders the economic rehabilitation of freed bonded labourers by the State.

Yet, despite the existence of this framework, critical gaps exist as India has not ratified ILO Convention No. 87 on Freedom of Association and Protection of the Right to Organize, or ILO Convention No. 98 on the Promotion of Collective Bargaining, and only ratified ILO Convention 182 on the Worst Forms of Child Labour in June 2017. Furthermore, implemen-

tation of the aforementioned regulations is partial at best and often completely ineffective as illustrated in the following sections.

To take into account disparities in the regulations of States this research has focused on Districts (as this is the level at which whatever information on mining title available can be accessed) located up to 150 km from Delhi NCT to reflect the high transport costs and price sensitivity of the sector. This area is henceforth referred to as the “supply area” and includes:⁵

▶ **Delhi NCT**

▶ **State of Haryana**

Districts of: Bhiwani, Faridabad, Fatehabad, Gurgaon, Hisar, Jhajjar, Jind, Kaithal, Karnal, Kurukshetra, Mahendragarh, Panipat, Rewari, Rohtak, Sonapat, and Yamuna Nagar.

▶ **State of Rajasthan**

Districts of: Alwar, Bharatpur, Churu, Hanumangarh⁶, Jaipur, Jhunjhunun, and Sikar.

▶ **State of Uttar Pradesh**

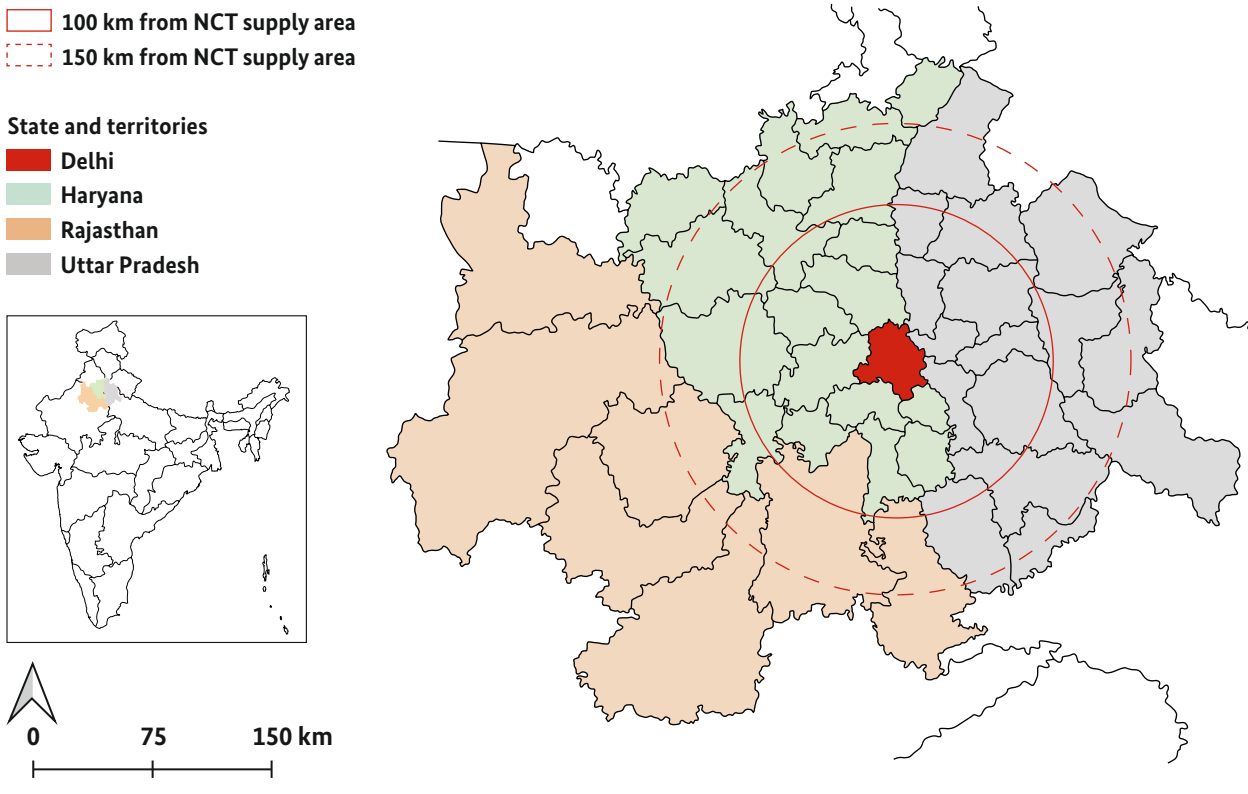
Districts of: Aligarh, Badaun, Baghpat, Bijnor, Bulandshahr, Gautam Buddha Nagar, Ghaziabad, Hathras, Jyotiba Phule Nagar, Mathura, Meerut, Moradabad, Muzaffarnagar, and Saharanpur.

The construction industry contributed somewhere between 22% of Indian total carbon emissions in 2006 (Maity et al. 2015) to 10% of its total carbon emissions in 2010 (ADB, 2015; MoEFCC, 2015; Jajal and Mishra 2018). To lessen this impact several government policies have come into play in recent times that encourage, incentivize and, where necessary, mandate the implementation of sustainability principles and practices in the construction sector. Climate change efforts have focused on the mitigation of CO₂ emissions through architectural and civil engineering design, as well as (to a limited extent to date) material

⁵ Note that, while falling within the 150 km NCT reach Haridwar district in Uttarakhand has not been selected in order to streamline the data collection and analysis.

⁶ While technically located a few kilometres further away from Delhi NCT than 150 km, the district of Hanumangarh is a critical supplier of gypsum, thus justifying its inclusion.

Map 1 – Delhi NCT area of supply



circularity,⁷ and much less so on climate change resilience or mitigation through sustainable sourcing.

One of these policies has been the formation of Bureau of Energy Efficiency (BEE), which formulated the Energy Conservation Building Code (ECBC) (Business World, 2019). The code aims to optimise energy savings with the comfort levels for occupants and prefers life-cycle cost effectiveness to achieve energy neutrality in commercial buildings. In order for a building to be considered ECBC-compliant, it would need to demonstrate minimum energy savings of 25% (MoEFCC 2018). The scheme has avoided 14.2 MW of consumption during the period 2006–2014 (CEA, 2018). The Ministry of Housing and Urban Affairs (MoHUA) and state governments are responsible for its implementation and enforcement (MoEFCC 2018). In parallel MoEFCC clearance is required for all buildings with a built-up area exceeding 20,000 m², this clearance is based on an EIA and its appraisal by the MoEFCC’s Environmental Appraisal Committees and the State

Environmental Appraisal Committees. In parallel the Ministry of New and Renewable Energy has initiated several programmes focusing on the utilisation of renewable energy sources in buildings (Business World 2019).

2.2. Indonesia

Indonesia is the 4th most populous country in the world. The population growth goes hand in hand with a strong urbanisation trend. The share of people living in urbanised areas grew from 22% in 1980 to 31% in 1990 (Supriadi and Sui Pheng 2018), 42% in 2000 and 54% in 2015 and is expected to reach 71% in 2030, meaning 209 million people (Asiagreen Real Estate n.d.). Indonesia counts 11 cities with a population of more than 1 million people. Indonesia was the world’s 16th largest economy in 2016 and is expected to be the 7th largest in 2030 and the 4th largest in 2050 (ITE Build & Interiors 2016).

Indonesia has important natural resource deposits, in particular oil and natural gas, coal, copper and nickel, gold and bauxite (van der Eng 2014). It also produces many different industrial or development industrials, including construction raw materials. Among the

⁷ Material circularity shows significant promise in decreasing CO₂ production as aggregates production from recycled construction and demolition waste has been shown to produce 40% less CO₂ than the quarrying, transport and manufacturing of hard rocks (GIZ 2016).

most important materials in terms of size of deposits and production volumes are sand, limestone and clay. The mining sector's contribution to the national economy has been falling in recent years due to certain legislative reforms (Wacaster 2014). Around 5% of GDP came from the mining sector in 2018 (PwC 2019). The mining sector is however often the largest contributor to local government revenues in areas where there is a large mine or important ASM activity (EITI Indonesia 2015).

Indonesia's construction sector is the third-largest contributor to the economy, providing around 11.1% of GDP in 2018, having grown from 6.5% in 2013 and 9.96% in 2016 (Oxford Business Group 2019; Abduh and Pribadi 2014; ITE Build & Interiors 2016). In January 2016, 7.72 million people worked in the sector (ITE Build & Interiors 2016). Something that triggered increased growth of the Indonesian construction industry was that the government under President Joko Widodo tripled infrastructure project funding in 2015 (HFW 2019; Oxford Business Group 2019). In 2018, the Ministry of housing, which is responsible for providing affordable housing to low-income households, received 26% of the infrastructure budget. The Ministry of Transportation received around 12% (Chong and Stefano, n.d.). Indeed, around 820,000–920,000 new housing units are needed every year in the country to meet the demand of a growing population. 400,000 units are built by the private sector each year, 150–200,000 are built through public sector initiatives, which leaves around 220,000–370,000 households having to rely on informal housing (ITE Build & Interiors 2016). Other infrastructure efforts include the Medium-term master plan (RPJM) and economic acceleration master plan (MP3EI) which made it a priority to create sustainable infrastructure better connecting six parts of Indonesia, including Java (Abduh and Pribadi 2014).

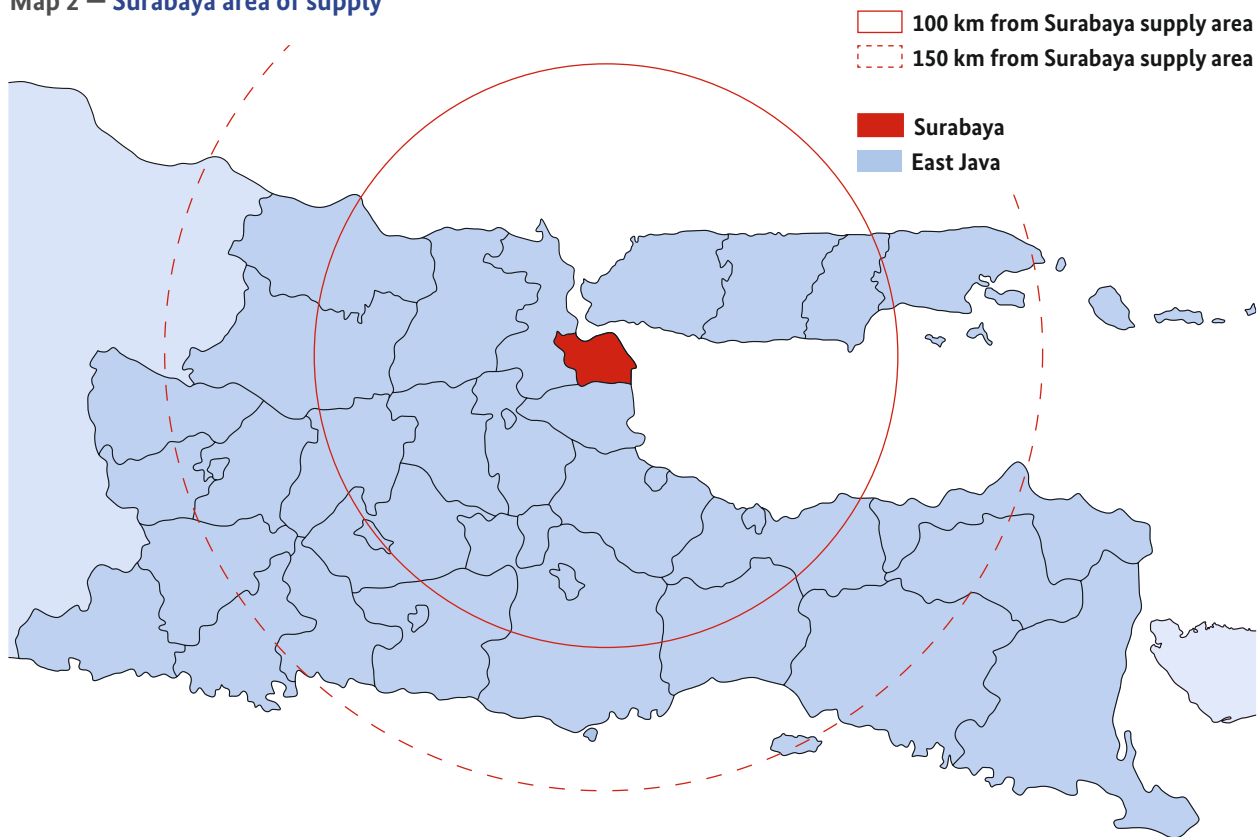
The best performing part of the construction sector is infrastructure development, with 60bn USD worth of projects having been given to Chinese investors as part of the Belt and Road programme, half of it for hydropower plants. Railway projects and toll-roads are other important infrastructure initiatives. The government has aimed at increasing private sector participation in infrastructure development, amongst others through Public Private Partnerships (Rahmansyah 2020). The second and third best performing construction sub-sectors are logistics and low-cost apartment buildings. In Jakarta for example, the government is planning to build 14,000 apart-

ments between 2019 and 2024 (Turner & Townsend 2019). And in 2015, the President announced the One Million Houses project, aiming at building at least one million houses per year, 70% of which for low income families. In 2018 the government exceeded that target, with 1.13 million new houses having been built. In 2015 it was 699,770, in 2016 805,169 and in 2017 904,758. 20% of the budget for the construction came from the government, in particular for low-income households, 30% came from a government mortgage programme, and 50% of houses were constructed with funds from individuals and companies (The Jakarta Post 2019).

The Indonesian construction sector consists mainly of small-sized companies. Firms are classified by their working capital. Small firms have a working capital of maximum 1,000,000,000 Rp., medium firms have a working capital between 1,000,000,000 Rp. and 10,000,000,000 Rp. and large firms a working capital above 10,000,000,000 Rp (Supriadi and Sui Pheng 2018). In 2013, there were 117,042 registered construction contractors, of which 89.9% were small-size, 9.4% medium-size and 0.8% large-size. However, the biggest share of construction projects in terms of value go to large contractors, namely 85% in 2012 (Abduh and Pribadi 2014). The Indonesian construction industry is composed of 269,000 full time employees and 4–5 million skilled and unskilled part time workers (Supriadi and Sui Pheng 2018). Indonesian companies face increasing competition from foreign firms, coming mainly from Japan, China, South Korea and India (Suraji, Pribadi, and Ismono 2012).

The metropolitan area which is the focus of this research is Surabaya, the capital of the East Java province. East Java is the second most populous province, but outward migration has kept the population growth low at an average of 0.7% per year between 2000 and 2010 (International Labour Office 2013). The rate was still at 0.66% in 2016 (Knoema n.d.). Employment rates are higher compared with other provinces in the country, and East Java has the second highest GDP after Jakarta. The province is structured into 38 districts and under those 29 regencies and 9 municipalities (International Labour Office 2013). The provincial capital Surabaya is the second largest city in Indonesia after Jakarta, with 2.85 million inhabitants (Asiagreen Real Estate n.d.). Population growth is around 0.65% per year, and population density 8,458 inhabitants per square kilometre (Ostojic et al. 2013). The construction industry contributes 10% to the city's GDP. The main industries in the city are trade, hotels, restaurants, and manufac-

Map 2 — Surabaya area of supply



turing (Asiagreen Real Estate n.d.). Outside of the urban area, in East Java in general, most people work in agriculture, namely four out of ten people (International Labour Office 2013). Surabaya's port has a high importance for the country and for Southeast Asia, with more than 3.2 million containers passing through the port in 2015. The average economic growth in the city was 7% per year between 2011 and 2015 (Asiagreen Real Estate n.d.). The city has a large informal sector across industries, with the formal sector only providing 44.1% of employment (Ostojic et al. 2013).

The area of interest for this study lies within a radius of around 100–150 km around the city of Surabaya, as demonstrated in Map 2.

Infrastructure development is an important sector in Surabaya. The Suramadu bridge between Surabaya and Madura Island has been completed in 2009 and an upgraded railway between Jakarta and Surabaya as well as monorails and trams are in planning. Local developers dominate the city's construction market. (Asiagreen Real Estate n.d.).

Surabaya's GHG emissions in 2010 totalled 8.6 million tonnes of CO₂ equivalent, of which 35% came from

industrial energy use. Surabaya received the 2012 ASEAN Environmentally Sustainable City Award and since 2006 the city has regularly received the highest environmental awards amongst all Indonesian cities (Ostojic et al. 2013).

An ILO report from 2013 points towards labour issues in East Java province, and can give an indication of what conditions we might find in the quarrying and mining as well as construction sectors around Surabaya. The information is general however, and needs to be backed up by sector- and geographically specific facts. Informal and vulnerable employment is widespread in the province, even though it is on the decline. Precarious work is more common in East Java than the national average, being at 13% in 2011. Women are most affected by instable and insecure working conditions. 40% of workers are in the low pay bracket, meaning they earn less than two-thirds of the median salary. Child labour rates are lower in East Java than on average in the country (3.5% in East Java, 4.2% nationally), which might have to do with the strong educational policies of the province. Representation of workers in unions is not very strong, neither in East Java nor in Indonesia in general (International Labour Office 2013).

3. Market study

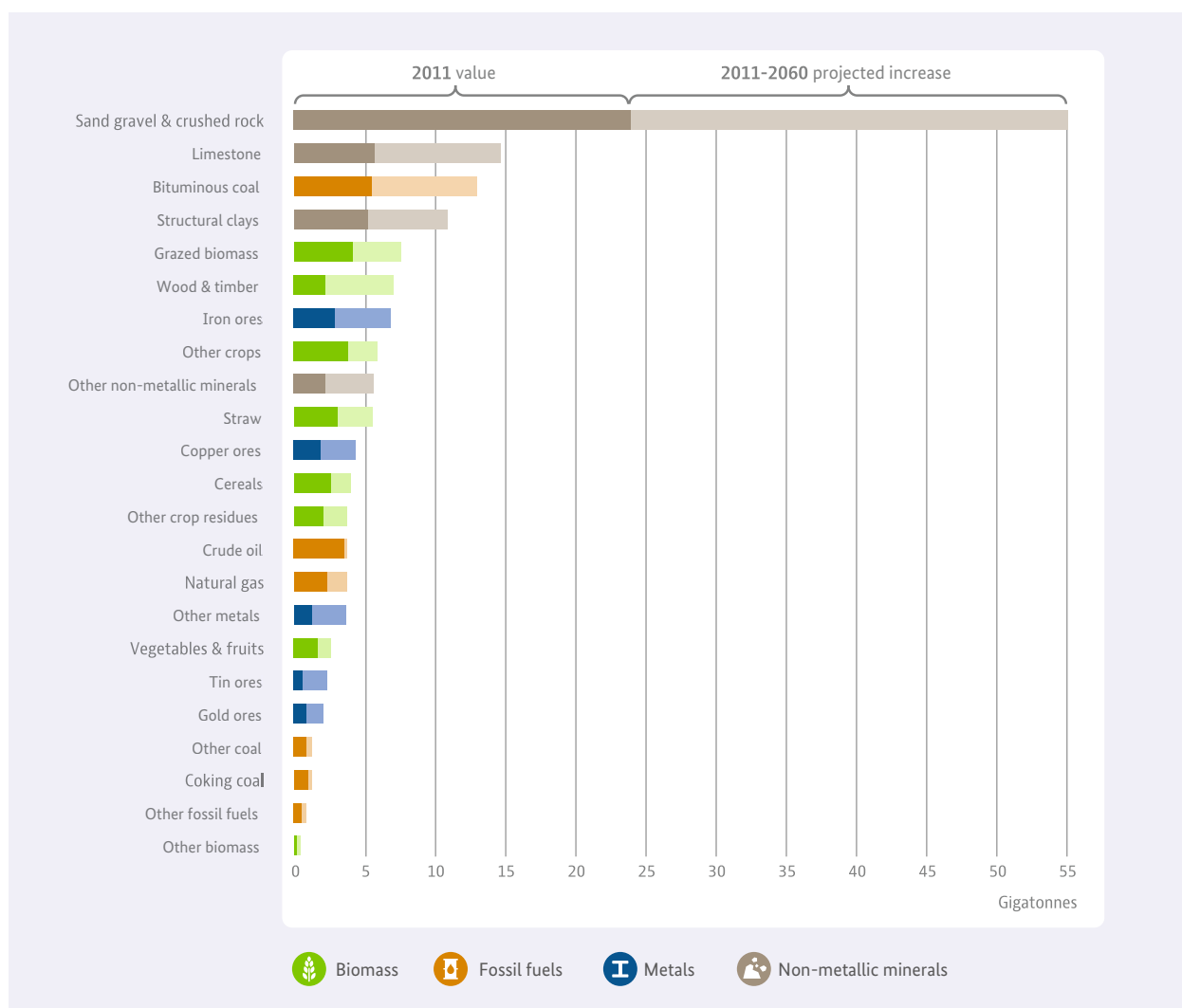
3.1. Material overview

As the processes of extraction and processing as well as manufacturing of the raw materials researched in this study are often similar or the same across countries, this chapter provides a general overview of the materials. It explains their composition, production and consumption, extraction, processing, and manufacturing, and how they are used in the construction industry. Basic information on India and Indonesia is added where available for those minerals which

will not be discussed in detail in later chapters. The chapter thereby lays the groundwork and basis for the country- and metropolitan area-specific information in the following chapters.

The following graph shows the dominance of construction materials in materials use across the world. In particular sand, gravel and crushed rock as well as limestone are already widely used and expected to rise even more in the coming decades.

Figure 2 – Material use in 2011 and 2060 (OECD 2016)



SAND AND GRAVEL

Sand and gravel are types of aggregates. Sand is a fine granular material whereas gravel is larger in size. Sand and gravel are extracted from pits or dredged from water bodies (Langer 2001). Sand from the sea and desert are not as suitable for the construction sector as sand from rivers, which is therefore the most popular, but also the most environmentally destructive form of extraction (Pearce 2019). The extraction of sand and gravel has grave environmental impacts, for example negative consequences for biodiversity, water turbidity, and the climate because of CO₂ emissions from transport. In Indonesia, whole islands have disappeared because of the illegal mining of sand (UNEP Global Environmental Alert Service (GEAS) 2014).

Basic processing of sand includes washing organic matter from the sand or reducing salinity of sand from the seaside. Gravel might go through one primary crusher and one or more secondary crushers, in case its size is too large for the intended use. Then the material will be washed, screened, or processed further to remove undesirable material (Langer 2001).

Globally, out of the 47 – 59 billion tonnes of material which is mined each year, sand and gravel are responsible for 68 – 85% of that, and their extraction increases the fastest. Global consumption of sand and gravel is estimated at more than 40 billion tonnes per year (UNEP Global Environmental Alert Service (GEAS) 2014). The materials have a low value per unit, but are large in quantity. Their value hence mainly stems from being located close to the market (Hilson 2016). Sand and gravel are used for the production of concrete, mortar and asphalt when mixed with a binding material (Langer 2001). Concrete is composed of sand, gravel and cement, sand and gravel making up around 75% of a tonne of concrete. Asphalt on roads is composed to 90% of sand, and concrete roads to 80%. Other uses of sand are land reclamation, for example in Singapore, or glass manufacturing (Pearce 2019).

More information on sand and gravel in India and Indonesia specifically is provided in the following chapters.

CRUSHED ROCK

Langer (2001) distinguishes different types of aggregates, namely sand and gravel as described above, and crushed rock. What distinguishes crushed rock from sand and gravel is that the material is produced by artificial crushing, as opposed to natural abrasion. There are four general types of crushed rock: lime-

stone (meaning carbonate rocks such as limestone, dolomite and marble), granite (true granite and other light-coloured rocks), traprock (volcanic rock including basalt) and sandstone (including metamorphic quartzite) (Langer 2001).

Crushed rock is extracted from open-pit quarries, involving blasting and potential secondary breaking at the mine site in case the pieces are still too big for crushing. Mined crushed rock is transported to the processing facility. The first processing step is the primary crusher, in which large rock pieces are broken into smaller pieces. Subsequent steps are one or more secondary crushers, reducing the size of the material to the desired shape. After each crushing step, the material is searched to separate pieces that are already in the desired size. Washing or other processing might take place to remove undesired material. The rocks are then moved by conveyers onto different stockpiles where they are stored until sales (Langer 2001, 2009).

Crushed rock is also available as recycled material, either as recycled concrete aggregate or as recycled asphalt pavement (Langer 2001; Glavind 2009). Processing is needed to recycle these materials as for example concrete usually contains steel bars which need to be separated by magnet, and cement paste which has different properties to aggregate. Recycled concrete is therefore not usually used to produce new concrete, but for low-specification uses (Langer 2009). Whereas the environmental benefits of recycling waste material are big, recycling can create dust, noise (Langer 2001) and CO₂ emissions from transportation. Further, the demolition and crushing processes require energy (Glavind 2009).

Crushed rock, like sand and gravel, is commonly used for producing concrete, mortar, and asphalt, being mixed with a binding material. Aggregates occupy about 72 – 75% of volume of concrete and they influence the strength of concrete – as do the particle size distribution, water contents and curing time. Other uses are as railroad ballast, road base, for blocks, bricks and pipes, as decorative stone, or as landscape rock (Langer 2001; Kumar et. al. 2015; U.S. Geological Survey 2020).

Crushed rock is low value, heavy and bulky, and transportation can have significant cost implications (Langer 2001, 2009), which is why they are often sold locally – even though an import/export business also exists. The transport of crushed rock is probably also the most energy consuming step in the value chain –

until its use in materials such as concrete. Using local materials helps to reduce CO₂ impact (Glavind 2009).

Environmental impacts of crushed rock extraction include landscape changes, noise, dust, vibrations from blasting, and water degradation (Langer 2009). The crushing of rocks often creates dust or water pollution in case the washing water is directly discharged into water bodies. Processing of rocks has significant impact on air pollution in the form of dust particles that results in pulmonary fibrosis and premature death of quarry and rock crusher workers (Kumar et. al. 2015).

More information on crushed rock in India and Indonesia specifically is provided in the following chapters.

DIMENSION STONES

Dimension stones, also called building stones by the British Geological Survey, are naturally occurring rocks which are consolidated enough for being cut into blocks or slabs. The main types of dimension stones are limestone, marble, sandstone, slate and granite (British Geological Survey 2005).

Dimension stones are extracted in quarries or shallow underground mines. Blasting is not used as it could negatively affect the structure of softer stones. Instead, naturally occurring openings in the rocks are used to open a quarry, and drilling and splitting or diamond saw techniques are employed to extract the stones (British Geological Survey 2005).

The processing of dimension stones can take place at the quarry or at a centralised cutting shed and consists of shaping or cutting by hand, or sawing with machines. Some stones might undergo polishing (British Geological Survey 2005). The main types of dimension stone products are blocks, coming directly from the quarry, or semi-finished slabs, finished tiles and cut-to-size products from the processing factory (Cosi 2015).

The main producers and exporters of dimension stones in 2001 were China, India, Italy, Iran and Spain, making up 74% of the world production (British Geological Survey 2005). In India, dimension stones like marble, granite, slate, limestone, and sandstone are used for building construction. Working conditions in Indian stone quarries present significant occupational health and safety (OHS) gaps. Most of the small mine operators are reluctant to adopt safety and health

measures and do not comply with the relevant laws. Silicosis is widespread among miners (Sharma 2015).

More information on dimension stones in Indonesia is provided below.

LIGHTWEIGHT AGGREGATES (PUMICE, PERLITE)

Pumice is a volcanic rock formed by the cooling-down of air-pocketed lava. It is lightweight, has low density and is porous. It is usually extracted in open pits, and processing includes drying, crushing and screening, or sawing blocks into different shapes (Crangle 2017). Pumice is predominantly used as aggregate in lightweight building blocks, but also for concrete aggregate or for abrasives. Global pumice production in 2018 was 18.1 million tonnes. Indonesia produced 770,000 tonnes of that (U.S. Geological Survey 2020).

Perlite is a siliceous volcanic glass which, when heated quickly, expands up to 20 times (USGS 2020). Perlite and pumice are closely related, with the main difference lying in their density, perlite being denser. The mining of perlite involves heavy machinery, cutting or blasting. Afterwards, perlite is crushed and subsequently heated for expansion respectively popping, which decreases its density (Bolen 2010). Perlite is mainly being used in building construction products and for filters or as horticultural aggregate. The world's leading producers of perlite are China, Greece, Turkey and the US, accounting for 96% of global production in 2019 (USGS 2020).

Not only pumice and perlite, but also other naturally lightweight materials such as vermiculite and scoria are used in place of sand and gravel in ordinary structural concrete mixes. The resulting light weight concrete is about one half the weight of hard structural concrete (Kakamare et al. 2017).

Perlite and pumice deposits are present across many provinces in Indonesia, but not including East Java. They are used widely as raw materials for light bricks and for sound dampening in music studios. The material is mined on a small- and medium-scale in open pit mines with simple equipment, and subsequently cleaned by hand. No perlite production has been recorded in India since 2007–8 (IBM 2020c). No more specific information about lightweight aggregates could be found for India and Indonesia.

SLATE

Slate is a fine-grained sedimentary hard rock that can be easily split with hammer and chisel into thin sheets

due to its natural composition. Similar hard rock materials are mudstones and shale. In fact, slate results from applying heat and pressure to those rocks. Slate consists of quartz silt and clay minerals. Slate is the most used roofing stone in the world. Apart from use for roof tiles, slate is also used in more decorative fields, as dimension stone, for walls, pavements, fire places or tabletops (British Geological Survey 2005; Merriman, Highley, and Cameron 2003).

Slate in India is a low-cost decorative stone used for exterior and interior decoration of buildings. It is also significantly used in roofing (IBM 2018e). The production of slate in India was at 218 tonnes in the year 2014–15 (up to January 2015) decreased by 38% as compared to that in the previous year due to decrease in demand (IBM 2018e).

Slate in Indonesia is mined mainly in the provinces of Aceh and West Sumatra, in small- and medium-scale mines. It is mined by sawing in blocks, and then cut in thin layers depending on its intended use. Slate in Indonesia is nowadays mainly used for wall and fence decoration.

CARBONATE ROCKS

Limestone is probably the main carbonate rock used in construction. Limestone is relatively soft, and there are various types (British Geological Survey 2005). One of the types is chalk, a very fine marine limestone (Bliss, Hayes, and Orris 2008). Marble is a limestone that has been recrystallized by metamorphism. In the construction sector the term marble often however is used to describe any hard and polishable limestone (British Geological Survey 2005). Dolomite is a limestone that contains a certain portion of magnesium (IMA Europe, n.d.).

Limestone is mined mostly in quarries, but also underground. Main environmental concerns are dust and noise pollution, blasting, vibration, and traffic. Limestone is used in construction as crushed rock, and as a key ingredient of Portland cement. Marble is used as a decorative stone mainly, travertine as a dimension stone, and certain white limestone is used in crushed form in roofing. Dolomites are used for industrial purposes, in concrete as an aggregate, or in asphalt, amongst others. Limestone is also a raw material for the production of lime, used to treat soils, for water purification and smelting of copper (Bliss, Hayes, and Orris 2008), as well as for mortar, and certain building blocks and bricks. The production of lime releases important CO₂ emissions (IMA Europe n.d.).

As for many other construction raw materials, the cost of limestone is mostly defined by how far it has to be transported, and by what means (Bliss, Hayes, and Orris 2008).

GYPSUM AND ANHYDRITE

Anhydrite is the anhydrous form of calcium sulphate, gypsum is the hydrated form. Gypsum is formed by the hydration of anhydrite at or close to the surface, anhydrite therefore lying deeper under the ground (Highley, Bloodworth, and Bate 2006).

Gypsum and anhydrite are produced by both surface and underground mining, depending on the location. After extraction, the material is screened and crushed. If the gypsum/anhydrite is intended for cement production, it is grinded with cement clinker. If it is intended for manufacturing plaster, it is finely ground on its own and then heated. Emissions of this process are only steam, the waste production during gypsum/anhydrite processing is therefore minimal. There is also synthetic gypsum, produced as a by-product for example of coal-fired power stations, which often has a higher purity than natural gypsum. It is now commonly used in the production of plasterboard (Highley, Bloodworth, and Bate 2006).

Gypsum is mostly used in the construction industry, for example for building plasters and producing plasterboard, as an ingredient of Portland cement, or for wallboard products. Wallboard is increasingly being used in Asia, which has increased production on the continent (U.S. Geological Survey 2019). In comparison to gypsum, anhydrite has limited uses and less economic value. It is often used however for the production of Portland Cement together with gypsum (Highley, Bloodworth, and Bate 2006).

The production of gypsum in India in 2017–2018 was 2,048,127 tonnes. In 2015, India had gypsum reserves of 36,621,000 tonnes (IBM 2020b). More information about gypsum in India can be found in the subsequent chapter.

In Indonesia, gypsum is almost to 100% being imported (Abduh and Pribadi 2014). This is despite gypsum reserves existing across many provinces of the country, including East, West and Central Java. Since the 1997 recession, the government has been trying to produce gypsum within the country, however with limited results. Gypsum is imported as a raw material and subsequently processed in Indonesia by formal

businesses, for use in Portland cement, plaster, walls and ceilings.

CLAYS

Clay is a fine-grained sedimentary rock that is characterised by its plasticity and ability to be easily cut or moulded (Merriman, Highley, and Cameron 2003). There are various types of clays, some examples being ball clay (used in floor and wall tile), bentonite (used as pet waste absorbent or drilling mud), common clay (used for bricks, lightweight aggregate or cement), fire clay (used for bricks or cement), fuller's earth (used as pet waste absorbent), and kaolin (used as paper coating and filling, for ceramics or paint and as catalysts) (U.S. Geological Survey 2020).

More information on the clay value chain in India and Indonesia is provided in the chapters below.

SILICA RAW MATERIALS

Quartz sand is commonly used for glass production, foundry casting and metal extraction, for the making of ceramics, chemical manufacture, or water filtration (Platias, Vatalis, and Charalampides 2014).

Quartz sand is found across many provinces in Indonesia, including East Java. There it is present in Tuban, Ngadon, Bumen, Tambakbayo, Tasikharjo, Malang, Jember, Bangkalan and Madura (Rumidi 1988). Across Indonesia, 27 legal businesses (with 634 people) produced 1,218,160 m³ in 2018, and 26 household businesses (with 876 people) produced 385,749 m³. The production value in 2018 was 282,846 million IDR for legal businesses and 26,747 million IDR for household businesses (Nuryati 2019). Quartz sand in Indonesia is usually used as a raw material for the production of cement, glass, and tiles to be used in construction.

Official production of quartz in India stood at 1,395,000 tonnes in 2013–14. The term 'quartz' is often referred to as a synonym for silica. In India, quartz sand is used in making glass and bricks. India exported around 61.5 million USD worth of quartz, which accounted for 13% of the global quartz export (Agarwal 2019). Workers not wearing the appropriate personal protective equipment (PPE) are at risk of "silicosis" in quartz, silica sand and gravel mines (IBM 2019f).

GLASS

Glass mainly consists of silica, the primary component of sand, as well as soda and lime. Typical glass used in the construction sector is composed of 69–74% silica, 5–14% lime and 10–16% soda, next to some minor in-

gredients like magnesia and alumina. Flat glass sheets are produced by blending the raw materials with recycled broken glass, and then heating the mixture in a furnace to around 1,600 degrees Celsius to form molten glass. The molten glass is then put on a molten tin bath and subsequently through an annealing lehr where it is cooled down and shaped into a certain thickness (Achintha 2009).

Glass is a more sustainable building material than concrete and steel, as it is more durable, less volume is needed, and glass can reduce the carbon usage of buildings. Glass sheets used in buildings are usually not recycled, as it is difficult to remove coatings and other materials that are being mixed with waste glass. Further, the energy savings are very low for the recycling of glass sheets. Glass can however be reused as an aggregate in concrete, or for road construction as well as for other purposes such as abrasives, aquarium sand, or in reflective paint. Reusing glass in that way is more sustainable than recycling it (Achintha 2009). Glass manufacturing therefore only produces low amounts of waste. The main source of carbon emissions in the glass sector is melting the raw materials, because of the use of fossil fuels and the decomposition of raw materials (IFC and CPLC 2018).

Significant increase in the use of commercial glass in construction of buildings in India is anticipated on account of its quality, easy installation and low maintenance cost as compared to traditional gypsum constructions (Research Nester 2020). This segment comprises of sheet plate float glass for residential and commercial construction, rolled glass, cast glass and other flat glasses which are used mainly for architectural and automotive applications. Flat glass, commonly called float glass after the process by which most of it is made, plays a dominant role in the Indian building construction industry (TERI 2012).

The flat glass industry in Indonesia had a reported production capacity of 1.34 million tonnes per year in 2019, up from 1.13 million tonnes the year before (Kementerian Perindustrian 2019). Three large companies dominate the Indonesian glass industry: PT Asahimas Glass with factories in Cikampek, West Java and Sidoarjo, East Java; PT Mulia Glass in Jakarta; and PT Tossa Sakti in Kendal, Central Java. Glass is mainly used for windows and walls. Glass waste is so far not widely used in Indonesia for further processing into other materials, and is mainly used as a raw material for handicrafts (Meilita et.al. n.d.).

CEMENT

Cement is produced by heating crushed limestone and other raw materials such as shells, chalk, shale, clay, slate, silica sand or blast furnace slag to a temperature of 1400–1450 degree Celsius in a cement kiln. The resultant Portland clinker is mixed with a small amount of gypsum and limestone and ground to cement (Glavind 2009; PCA n.d.; Bliss, Hayes, and Orris 2008). There are two processes to produce cement, one is a dry process and the other a wet process, where water is used to grind the raw materials (PCA n.d.).

There are different types of cement, with various compositions of cement clinker and other materials such as fly ash, blastfurnace slag or pozzolanic material. According to the British Standards Institution for example, these types are Portland cement (the most commonly used type), blended cements, blastfurnace cement, Pozzolanic cement and composite cement (British Geological Survey 2014).

Cement is used for the production of concrete, but also for mortars and stuccos (U.S. Geological Survey 2020). Concrete is the globally most used material, with 10 km³ per year. The projected increase of global demand for Portland cement between 2010 and 2050 is 200% to around 6,000 million tonnes per year (Pacheco-Torgal and Labrincha 2013).

The high temperatures in cement production mean that waste materials are combusted completely, and there is very low pollution. The carbon impact of cement production is significant, however. The production of cement clinker is particularly high in energy consumption. Per tonne of clinker produced, around

800–900 kg of CO₂ are emitted (Glavind 2009). The cement industry's contribution to global greenhouse gas emissions nearly doubled between 1990 and 2010, from 2.8 percent to 5.5 percent, which can largely be attributed to China's increased cement production. In 2017 the cement industry was responsible for 7% of global CO₂ emissions and the third largest energy consumer (IFC and CPLC 2018). Portland cement is responsible for almost 80% of the total CO₂ emissions of concrete (Pacheco-Torgal and Labrincha 2013). Concrete itself is responsible for 9% of global greenhouse gas emissions. Its impact per kilo is smaller than the impact of metals, but the sheer volume of concrete production makes its total emissions higher (OECD 2018). The cement industry is listed by the Indian central pollution control board as one of the 17 most polluting industries in India.

Nowadays blended cements are becoming more popular. They replace clinker with other materials such as granulated slag from the production of pig iron, fly ash from coal power plants or uncalcined limestone. This has positive effects on the CO₂ emissions. Alternatively, new clinker types use alternative compositions to lower CO₂ emissions of cement production (Glavind 2009).

2018, worldwide there were 4,050,000,000 tonnes of cement produced (U.S. Geological Survey 2020). In 2018–2019, 337,320,000 tonnes of that were produced in India (IBM 2020a), making it the second largest producer after China, and 75,200,000 tonnes in Indonesia (U.S. Geological Survey 2020). The International Energy Agency expects a 12 percent increase in the global production of cement by 2050 (IFC and CPLC 2018).

3.2. India

3.2.1. MATERIAL SELECTION

The following mineral commodities have been selected for further analysis. Their extraction, processing, manufacture, trade and final usage will be detailed in the following sections. Note that in the value chains presented below elements not highlighted in green are not discussed specifically in this report but nevertheless shown to accurately represent the respective supply chains. The visual representations of the value chains must be regarded as preliminary and simplified and will be refined as further information is gathered on the specific actors involved and processes taking place in the selected metropolitan area in the second research phase.

will refer to clay containing soil unless more specific detail is provided.

Sand is an important component of concrete, and while exact estimates of its trade are missing in all likelihood the most traded mineral in India by both volume and value if the country mirrors international trends. Sand is also a key component in the manufacture of fly ash bricks and concrete blocks, two alternatives to the use of clay bricks. Sand extraction is a mostly informal if not illegal sector that will continue to exist to satisfy the needs of the construction sector. Due to the low value per volume of sand its extraction will have to take place in close vicinity to Delhi NCT. Given the massive environmental and human impacts of sand extraction at its current rate, presented in the following sections, it is critical to better understand

Figure 3 – Clay value chain India

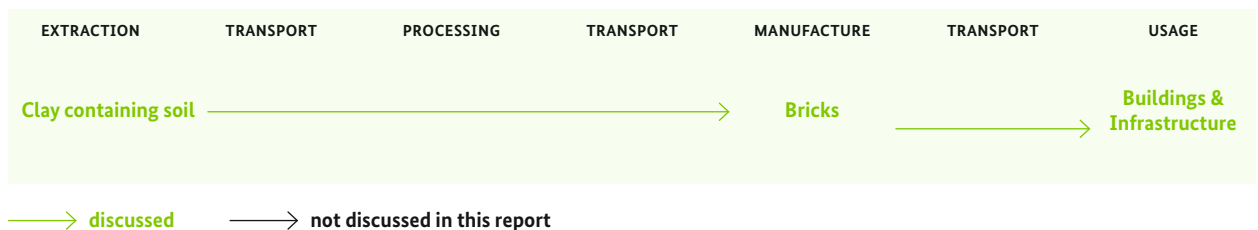
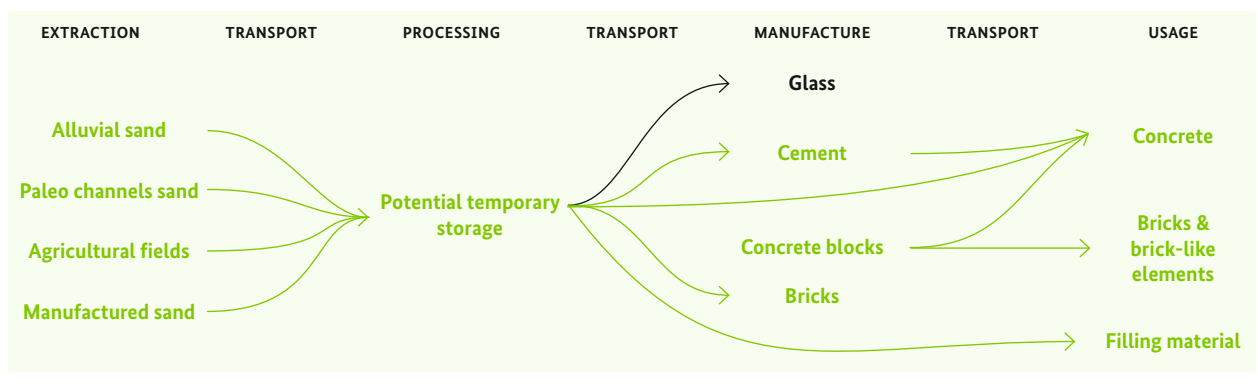


Figure 4 – Sand value chain India



Clay, or more specifically clay containing soil, has been selected for further analysis as bricks manufactured from it are a key component of exterior and interior walls. The sector also employs an estimated 10 million migrant workers while also being riddled with issues of forced labour and child labour at the manufacturing level. Policies from the Government of India are being implemented to incentivise a shift from clay bricks towards fly-ash bricks, which are based on a coal-burning polluting by-product. Note that throughout this report clay in the Indian context

the sector in order to mitigate its impacts. Moderate efforts are being made in India to promote the use of manufactured sand, fine aggregate resulting from the mechanical breaking of hard rock such as granite.

Crushed rocks are necessary in the manufacture of concrete and offer an opportunity to profitably re-purpose waste from dimension stone mining as well as having the potential to upcycle construction and demolition waste. Rock extraction has generated

Figure 5 – Crushed rock value chain India

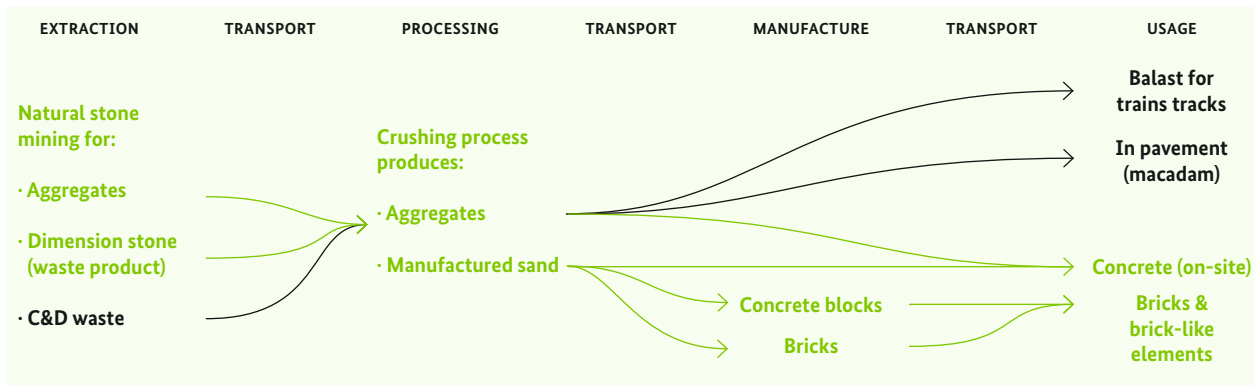


Figure 6 – Limestone value chain India

[Note that the use of “?” denotes information that is currently unknown but that the project aims to collect during fieldwork]

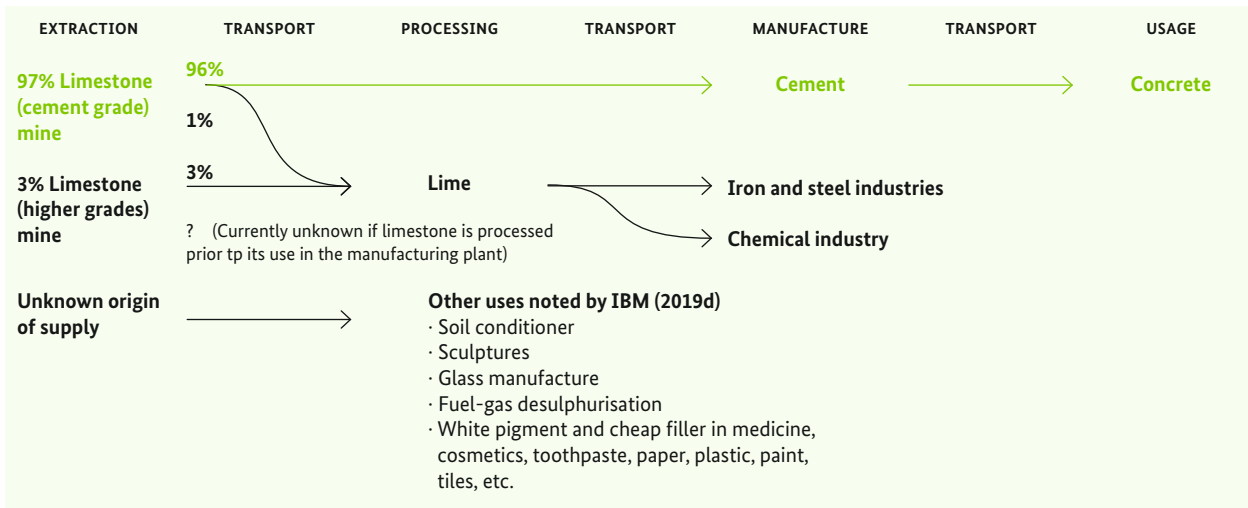
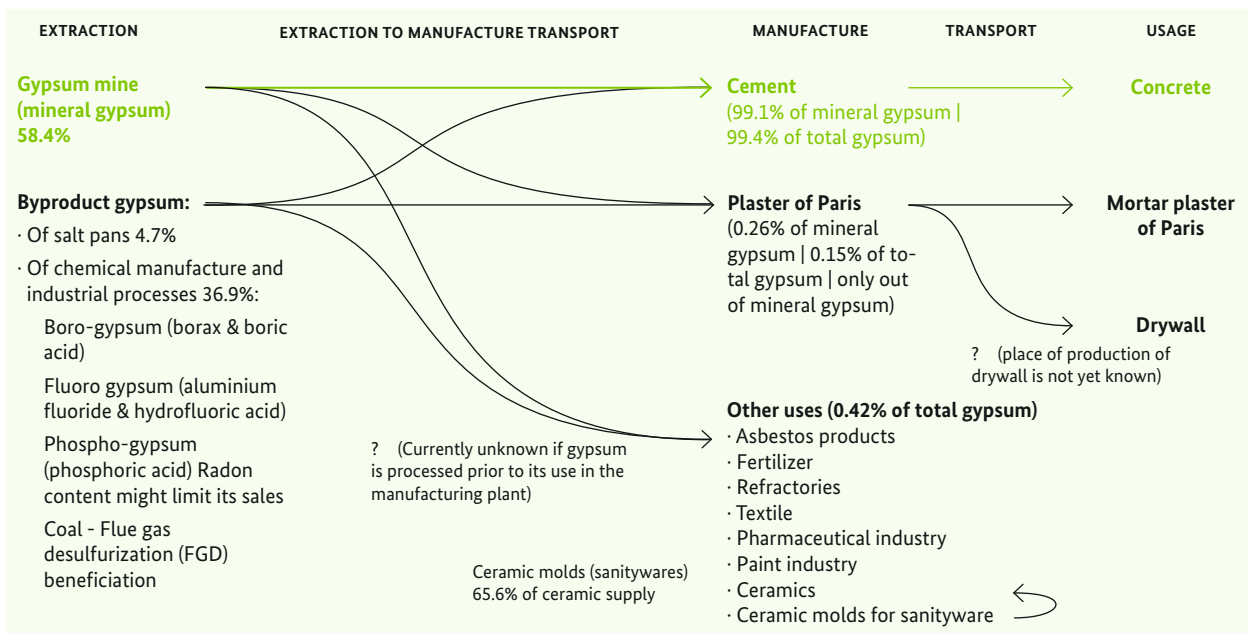


Figure 7 – Gypsum value chain India

[Note that the use of “?” denotes information that is currently unknown but that the project aims to collect during fieldwork]



significant social and environment impacts in the area of supply, including in the direct vicinity of Delhi NCT.

Limestone is the key material in cement manufacturing and the contributor to most of cement manufacturing's CO₂ generation through its calcination process. There are currently no known alternatives to the use of limestone in the manufacture of cement. In addition to that limestone finds usages in a variety of industries including: agricultural, pharmaceutical, paint, cosmetics, glass making, steel making. It is also used in everyday objects such as paper and toothpaste, although its usage outside of cement manufacture are very limited in India.

Gypsum is another key component of concrete and of lighter materials such as plaster of Paris and dry-wall whose usage is likely to increase with the transition towards lighter construction methods.

3.2.2. EXTRACTION AND RECYCLING

Due to the similar nature of their extraction process and associated impacts the minerals of interest have been clustered as follows: clay (including: brick earth, fire clay), sand, rock (including: limestone, gypsum, and crushed rock composed of: limestone, dolomite, granite, marble, feldspar, sandstone, and quartzite (GIZ 2016).

With the exception of some types of limestone all the minerals considered in this section are minor minerals according to Indian legislation.⁸ As a result, the applicable regulatory framework may differ. For example, while in Haryana and Uttar Pradesh extraction sites oversight is the responsibility of District level agencies belonging to their respective mining authorities, in Rajasthan it is the responsibility of the State's Department of Mines & Geology (MoM 2018). In the case of Delhi, the picture is not as clear as no authority responsible for mineral resources oversight has been identified, nor has an overall mining authority. At most it has been established that sand mining leases were granted by the Revenue department (MOEFCC

2016), but this contrasts with the Delhi Minor Mineral Rules (1969) which place this responsibility under the Director of Industries.

India does not import crushed rock, sand, or clay but does import gypsum to the tune of 4,068,412 tonnes in 2015 – 16 (IBM 2018a) and limestone to about 20.83 million tonnes in 2017 – 18 (IBM, 2019a).

In the case of gypsum, it should be noted that mining only represents 58.4% of India's gypsum production, this is complemented by the production of gypsum as a by-product of salt pans (4.7%) and of several chemical production and industrial processes (36.9%), such as: borax and boric acid production, aluminium fluoride and hydrofluoric acid production, phosphoric acid production, and flue gas desulfurization in fossil fuel plants, including coal plants.

According to the Indian Minerals Yearbook 2015, published by the Indian Bureau of Mines (IBM), sand production in the country in 2014 – 15 was 2.1 million tonnes. This figure is a clear underestimation of the actual production as domestic sand demand in 2016 was calculated to be at 750 million tons and estimated to double by 2020 (GIZ 2016), illustrating the size of the non-regulated sand sector. The demand-supply gap of sand is compensated by the informal and/or illegal sand mining industry in India, which is thought to fetch 250 million USD (Rupee 1,611 crore) every year (ABC 2017). Sand is primarily used for concrete and paved roads in the construction sector. The first import of sands to the country have been made in 2017 with Tamil Nadu, Karnataka and Kerala importing 55,000 tonnes, 54,000 tonnes and 45,000 tonnes of sand, respectively, from Malaysia (The Tribune 2019).

In the case of sand, identified sources of supply in the area of interest include: riverine deposits in Uttar Pradesh and parts of Haryana along the Yamuna river, agricultural fields in Haryana, and paleo channels (remnants of an inactive rivers) in Rajasthan (MoM 2018). Due to the amounts of sand required for the development of India's housing stock and its supply constraints Indian authorities have started promoting alternative materials in the manufacture of concrete, such as sand manufactured from the mechanical grinding of hard rock (M-sand) and fly ash, a powdered by-product of burning pulverized in coal plants. In contrast to certain States, Haryana, Rajasthan and Uttar Pradesh do not have dedicated policies for M-sand (MoM 2018; GIZ 2016).

⁸ At this point in the research it was not possible to ascertain how the distinction between the types of limestone falling under the major and the minor minerals worked in practice. According to the Mines and Minerals (Development and Regulation) Act, 1957 Limestone used for industrial purpose falls under 'major mineral', while the use of limestone in lime kilns and for building purposes comes under 'minor mineral'. However, we could not find any indication on when, how, and by whom this is determined in practice.

In the case of crushed rocks, these could also be formed of construction and demolition (C&D) waste, however until recently the Bureau of Indian Standards (BIS) standard for concrete aggregates (IS: 323-1970) only accepted aggregates that were ‘naturally sourced.’ This has strongly impacted the development of a C&D waste recycling sector until now.⁹ While C&D waste aggregates remain uncommon the bulk of aggregates originate from the breaking down and controlled grinding of hard rocks. Very limited information on hard rock quarries for aggregates is publicly available and is limited to brief media reporting on their illegality and negative impacts. There is however some more in-depth CSO literature on hard rock quarries for dimension stones, which have a substantial export in markets where human rights consideration are starting to be relevant. Not only do dimension stone quarries also produce material for aggregates as a by-product, but their operations and impacts are very similar to those of crushed rock quarries as they both mine hard rock. As a result this research makes use of reports on dimension stones mining to characterise crushed rock practices and impacts.

This lack of information on production translates into a lack of information on livelihoods generated by the sector. The limited information available point to a sector employing vast numbers of the rural poor. Delve (2019) for example estimates based on official numbers that ASM quarries provide livelihoods to more than 10 million Indians while Aravali (2018) estimates that Rajasthan’s mining sector alone might employ 2.5 millions, and IBM estimates that the dimension stones sector employs more than a million direct workers (IBM, 2018e) and values the granite industry at 40 billion USD while highlighting its employment generation potential in rural areas (IBM 2019b). Limestone classified as a major mineral provided employment to about 20,000 people in 2018 (IBM 2019d), no numbers are available in regards to limestone classified as a minor mineral.

Information collection in the sector is complicated by differences in the applicable regulatory frameworks between States, this includes differences in the nomenclature of minor minerals, as well as high informality rates in the sector. Delve (2019) estimates that up to 80% of the Indian ASM sector is characterised by informality or in Indian terms is “unorganised.” Unorganised mining operations are “mostly handled by

small companies and in majority of cases these enterprises do not adhere to sustainable mining standards mainly because of chaotic regulatory hurdles, corruption, governance failure, lack of supervision coupled with financial and technological constraints” (ICC and CUTS 2018). This predominance of the unorganised sector reflects the state of the Indian rural economy at large.

The informality of the sector, along with State level administration of the minor mineral resources make media, academics and NGOs a central source information; however these come with non-negligible limitations. Even if published recently, academic writing is often based on mine-site descriptions that are 10 to 30 years old and thus potentially not representative of the current state of a dynamic sector. Available NGO reporting is generally very localised and in the rock sector geared towards the type of dimension stones for export and whose final buyers include European or American buyers (granite in Southern India or sandstone in Rajasthan). Extraction of rock for internal consumption is somewhat covered by media reporting although it tends to focus on sand extraction. This media reporting while central is quite limited as reliable reporting centres on the interest of the big urban centres and when looking at the sector focuses on the impacted communities. Supply chain information is lacking, and multiple gaps remain in-between the pieces of known information.

The informality of the sector while being environmentally and socially detrimental lowers the barriers to entry and ensures that the sector provides livelihoods, however exploitative they may be, to some of the poorest segments of the population: migrant workers, scheduled casts and scheduled tribes (SCST) members, and recently rural villagers in drought affected areas (GITOC 2019). Siddiqui and Lahiri-Dutt (2015) estimate that more than 42% of the households engaged in mining and quarrying (approximately 1.4 million people in total across India) are considered to be living in extreme poverty.

Being minor minerals, responsibility for adapted policy and regulation design, monitoring and enforcement sits at the level of the different state authorities, and direct implementation often sits at the district level. Layers of governance that have access to a much narrower pool of resources when it comes to monitoring and enforcement. A particularly problematic point is the staffing of these agencies at the District and Sub-District level. These agents are in charge of

⁹ Interview with Sanjay Seth, Megha Behal, and Ankita Bokhad.

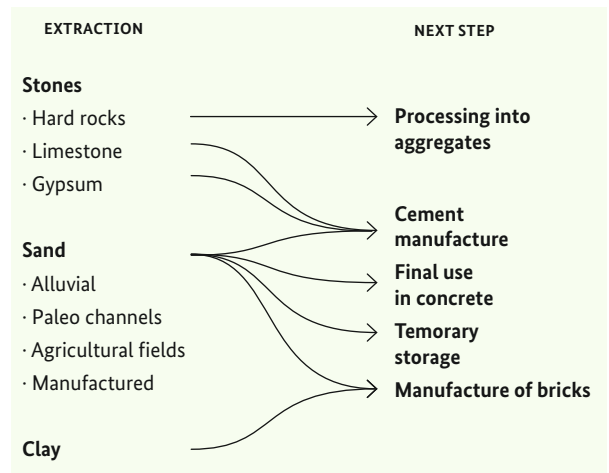
monitoring and enforcement in rock, clay, and sand extraction sites but they are, as a rule, stretched incredibly thin to the point that they cannot do their work, lack means of transportation to visit the extraction areas regularly, and are staffed by candidates that could not obtain a more prestigious posting and are often easily corruptible. The few civil servants bent on doing their duty are often promoted sideways to new postings where they will not be able to cause any trouble.¹⁰

Illustrating these issues, a recent Comptroller and Auditor General of India report (CAG 2019) focusing on Haryana has highlighted notable shortcomings. And while the issues found in Haryana are not necessarily the same as the ones found in Rajasthan and Uttar Pradesh this general pattern of issues is nevertheless informative:

- ▶ Multiple lapses of the Mines and Geology Department have led to a loss of revenue to the State amounting to more than 178 million Euro (Rupee 1,476.21 crore) from 2012 to 2017
- ▶ The absence of an internal audit wing, despite a previous CAG audit pointing out its absence in 2004. No remedial action had been taken since.
- ▶ A number of districts with substantial mining activity had vacant positions while 20 staff were posted in districts where no mining license was registered.

¹⁰ According to interviews with Prem Mahadevan and Thangaperumal Ponpandi, also see Rege (2015).

Figure 8 – Extraction and follow up steps of stones, sand and clay



- ▶ There was 80% vacancy in mining accountant and clerk positions, affecting the maintenance of records and tax recovery monitoring.

Extraction of minor minerals generates revenue at the District and State level through the collection of taxes at the State level (to the difference of major minerals), livelihood opportunities for local population, and provides inputs for local industries, chiefly among them construction. As a result mining activities are seen as an economic development engine to be encouraged by States, for example, the Haryana government has attempted in 2019 to open up part of the Aravalli Hills to industrial, mining, and industrial development, attempts that were stopped by a decision from the Supreme Court (SC) following cases from environmental activists (Down to earth 2019). This discrepancy of priorities between economic develop-

LOCAL EXTRACTION, LOCAL IMPACTS

The Aravallis are a hill-chain located West and South-West of Delhi, a part of which forms the Delhi ridge, a natural feature part of Southern Delhi NCT. Along with the Yamuna River the Aravallis is one of the two natural features located in this research's area of interest that is mentioned in Delhi medias with some regularity. Incidentally both are substantial sources of informally extracted stone (Aravalli Hills) and sand (Yamuna River) for the local construction industry, which would include Delhi NCT. And both play a role in the city's provision of ecosystemic services. While the Yamuna provides the city's water and serves as its wastewater evacuation, the Aravallis help to contain the advancement of sand from the Thar desert (Down to earth 2019; Reuters 2018). However, as both are thoroughly exploited, and likely to provide Delhi with a substantial percentage of its sand and rock aggregates, they have been damaged to a significant extent by these industries. For example, in the District of Alwar (Rajasthan) out of an observed sample of 128 hills 31 have disappeared due to mining since 1967 according to a report from SC (Times of India 2018). It should be noted that the Government of Rajasthan contested these claims, insisting that 28 of these hills had disappeared prior to 1960 and that no illegal mining was taking place in the area (Times of India 2018; DNA India 2018).

ment and preservation of natural capital between the State and the Federal level is an observable pattern in the governance of sand (GITOC 2019) and other minor minerals. For example, the NGT was instrumental in closing environmentally destructive mines, which led to livelihood losses and associated social unrest in north-eastern India (Delve 2019). And recently both SC and NGT have issued blanket bans on mining in parts of the area of interest. As a rule, these bans have not had a strong impact on the ground as States have not devoted sufficient resources to their enforcement (Down to earth 2019a; CAG 2019) or have even in certain cases been noted as exploiting loopholes to make their implementation partial. This includes re-classifying forested land under other land usage categories to avoid licence granting falling under the remit of the MoEFCC or prolonging expired mining titles without renewing them (Down to earth 2019).

In line with the aforementioned narrow economic development focused approach of the States, no measures to mitigate climate change at the extraction step could be identified. At the extraction process CO₂ emissions are concentrated in the use of machinery and any deforestation required by the extraction process. This preference for local economic development is reflected in the attitudes of most local dwellers who must focus on day to day survival over long-term impacts, even when cognisant of said impacts.¹¹

Extraction represents the first step in the supply chain and is thus shared by all materials. However, the destination of these materials after extraction varies markedly based on the next step in the value addition process.

Due to its innate characteristics the extraction steps concentrate most of the negative impacts of construction materials supply chains, while at the same time generating fewer revenues per unit of material, and thus unit of impact, than activities further downstream in the supply chain.

CLAY

In 2018, India produced 800,000 tonnes of bentonite (of 18,500,000 tonnes globally), 6,000 tonnes of fuller's earth (of 3,220,000 tonnes globally), and 4,000,000

tonnes of kaolin (of 42,200,000 tonnes globally) (U.S. Geological Survey 2020). Clay in India is used for making, porcelain, sanitary ware, floor and roofing tiles. Clay containing soil is used to produce fire bricks. Forced and child labour are endemic to the brick manufacturing sector (Anti-slavery 2015).

Clay extraction processes are mostly overlooked by secondary sources, with information concentrating on its environmental and social flashpoints: brick kilns. Extraction processes take place in close proximity to these kilns to reduce transport costs (GIZ 2016). Clay extraction is based on an agreement entered between the kiln owner and the agricultural landowner; this agreement specifies the area of the concession and in theory the kiln owner is required to acquire a permit from the State Environmental Impact Assessment Authority before excavating soil from agricultural land (GIZ 2016) but with the exception of brick earth mining titles in Hanumangarh District (Rajasthan) no information on clay extraction titles or authorisation could be found for the entire area of supply, suggesting that the mandatory clearances are not obtained.

While norms from MOEFCC exist regarding the depth of extraction, which is limited to 2m, these are seldom followed in this unorganised and loosely monitored industry, extraction areas are also not back filled as a rule (GIZ 2016). IBM information on Fireclay and Kaolin extraction while sparse clearly highlight the fully manual nature of the extraction process in clay mines (IBM 2017; IBM 2019c).

Clay's extraction stage does not include the on-site transformation of clays into bricks (see section 3.2.4. on manufacturing). Praxis and Partners in Change (2017) note that the preparation of clay for bricks (understood to be the extraction process) is undertaken by local workers, who do not live on the kiln site. Based on this limited information it is assumed for the time being that, in addition to issues related to competing land uses and the modification of landscape, issues are reflective of the Indian rural sector at large.

Competing land uses. Clay extracted for brick manufacturing forms part of the soil used for agricultural activities thus creating a competition in the use of the resource. And while this topsoil is refilled through floods, the current rate of extraction surpasses the rate of replenishment leading to diminishing stock and agricultural land (GIZ, 2016).

¹¹ Interview with Kuntala Lahiri-Dutt. Also see Rege 2015: "As one laborer stated, 'What is a sanctuary?... What is a mammal? What is a bird?' I don't have time to worry about these things" (AP 2015, p. 4).

Modification of landscape. Lack of back-filling in clay extraction creates stagnant ponds during the monsoon providing perfect breeding grounds for water-borne diseases and disease vectors such as mosquitoes (GIZ, 2016).

SAND

Three different patterns of sand extraction emerge based on consulted stakeholders and reports:¹² large-scale night time mining, daytime small-scale mining, and daytime large-scale mining.

Small-scale mining is conducted manually and is generally destined for local construction activities, whereas large-scale mining is heavily mechanised, making use of backhoes or dredges to extract sand from the riverbed (Rege 2015). In Uttar Pradesh mechanized mining requires the sign off of a District Magistrate (MoM 2018).

While night time activities are conducted outside of any extraction title under cover of the night, daytime activities are either tolerated as local officials turn a blind eye to an activity that allows poor villagers to build affordable housing (GITOC 2019), or take place within the framework of an official extraction title. In the latter case however, extraction of sand tends to either extract more than the allotted extraction threshold, or take place outside of the borders of the title. Despite not complying with the applicable law these operations benefit from all the advantages of officialdom granted to them by their title, and with the limited controls enacted by State governments can usually proceed unhindered for a long time.¹³

Where river bed mining is possible, the operations are open cast and trucks are simply filled prior to departure. In cases where sand is sourced from paleo-channels, as in Rajasthan, the removal of 5–20m of overburden must first be done with machinery and it is likely that the sand will have to be sieved and washed to remove debris (MOEFCC 2016).

Competition for land use has not been noted as an issue directly but may arise in Haryana as part of the state reserves are under agricultural land (MoM 2018).

Groundwater depletion caused by sand has been noted as an issue across large parts of India (GITOC 2019; MoM 2018). Sand acts as a natural filter of surface water and a diminution of this layer can lead to the pollution of aquifers (MoM 2018).

Modification of landscape. Over-extraction of sand from rivers can shift the course of rivers (MoM 2018) as in the case of the Yamuna river (CAG 2019), impacting agriculture dependent communities on its banks who lost part of their land and livelihoods (The Hindu 2016). Loss of livelihoods triggered by changes in landscape can make destitute farmer more vulnerable to exploitative employment practices (GIZ 2016). Extraction induced changes to a river's stream speed and banks can directly impact critical infrastructure such as bridge supports, pipelines, levies, or other structures, and changes in concentration of suspended sediment can lead to the siltation of water projects (MoM 2018). Four bridges, two canals and one barrage were damaged across India in 2018 due to sand mining (The Tribune 2019), all types of infrastructure that can be critical in mitigating the impacts of climate change. Delhi, receiving part of its drinking water supply from the extraction intensive Yamuna, is vulnerable to impacts on the river's upstream flow.

Impacts on fauna and flora of river sand extraction are not limited to the impacts on aquatic life (fish, insects, amphibians, flora) but also affect the riparian habitat and its associated species (birds, mammals, reptiles, insects, etc...) These impacts are caused by changes in: water flow speed, sedimentation, levels, and river course (MoM 2018).

Worst forms of child labour are reportedly common in sand extraction according to sources cited in GIZ (2016) but not accessible at the time of writing. The Times of India (2013) reports that in Maharashtra "child labor was also used on occasion, and children as young as 10 years of age worked for over 6-hour shifts loading and unloading illegally mined sand into trucks, which offered quick money".

Occupational health and safety includes issues related to silicosis (see sub-section on rock) and cancer. Some sand mine labourers also work as divers, extracting material from the bottom of the river with no form of safety equipment (GIZ 2016), which has led to deaths in the past (Rege 2015).

Corruption and bribery are reported as routine in the sand extraction sector by both NGO and media,

¹² Based on a phone interview with Prem Mahadevan and a review of the different cases summarised by the South Asia Network on Dams, Rivers and People (<https://sandrp.in/>).

¹³ Interview with Prem Mahadevan.

and one of the reasons behind the lack of oversight of extraction areas, in combination with lack of resources (Rege 2015). The issue of possible cartel formation during the auction of sand mining titles has been noted by MoM (2018). In addition to bribes paid to local civil servants, politicians are reported to support the operations of big construction companies as they receive significant funds and electoral support from those companies, support that when required extends to the suppliers of these companies. GITOC (2019) describes the following situation:

“The abundance of sand supply depresses profit margins and provides an incentive for government ministers to stay one step removed from the illicit extraction side of the business. Instead, they indirectly patronize it by maintaining close ties with their client base – the builders who purchase illegally and extra-legally mined sand. Not coincidentally, these builders sit atop large construction companies that undertake infrastructure projects offering multiple opportunities for corruption. In return for donations to political parties, the builders exploit their proximity to policymakers and thus deter law-enforcement personnel from pursuing them. [...] In effect, permission to mine sand in India – legally or otherwise – means being part of a web of patronage. The formal letter of the law counts for little. To sustain their own profits, politicians restrict the number of mining permits issued to legitimate traders in order to push up sand prices and boost the profits of illegal and extra-legal mining. By periodically ordering police crackdowns on the lowest, artisanal level of the supply pyramid, they concentrate revenues in favour of well-connected companies”.

Notably arrest made in operations against illegal sand mining do not identify the owners of seized trucks, suggesting that the big players benefit from some form of immunity (Rege 2015).

Misdeclaration of origin of minerals occurs with sand until it is traded for the first time, a process during which it is “legalised.”¹⁴ Hiding stone from dubious origin under sand to transport it to crushers has been observed in Haryana (Times of India 2018a).

Violence or threats thereof, contrary to the South of India where most of the media reporting is taking place, northern India, and Uttar Pradesh in particular, have been noted as having more violent cul-

tures which can put interlopers at risk. This can take the form of (un)armed muscle or of corrupted police agents, the latter having been noted as representing the highest risk to media and activists.¹⁵ Between 2015 and 2018 7 journalist that were working on issues related to mining, predominantly sand but also rock, have been killed in India (Thakur Family Foundation 2019). Attacks on police officers involved in the fight against illegal sand mining have taken place either during or after interventions, some of these have been carried out with seemingly lethal intent (Rege 2015).

ROCKS

While information on rock mining leases is more readily available than on clay or sand, it is unclear at the time whether patterns of hard rock, limestone and gypsum licences attribution mirror the location of informal rock extraction operations and therefore if the maps presented in Maps 3 – 5 are representative of the spread of activities.

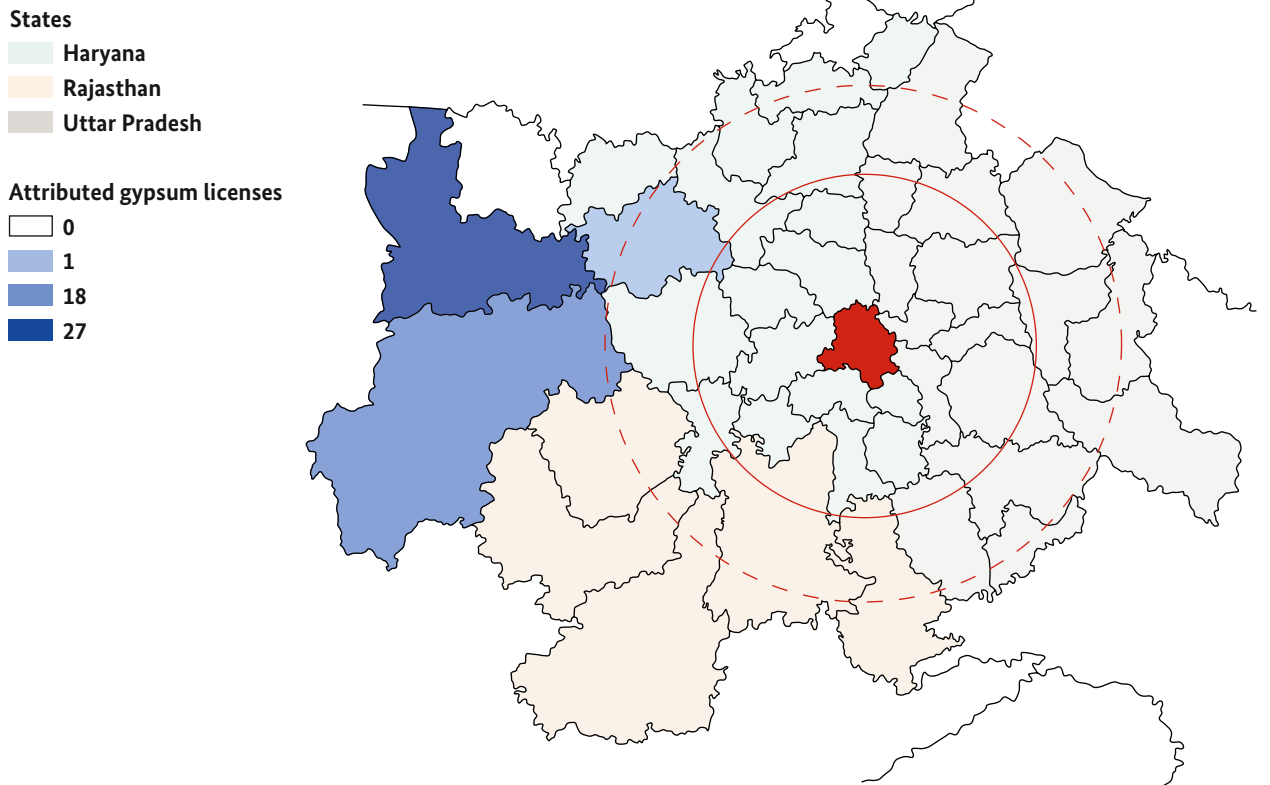
A seasonal activity as monsoons impede the extraction work, dimension stones extraction in India is characterised by open pit extraction relying on substantial amounts of manual labour but making use of machinery to conduct some of the activities (IBM 2018a; IBM 2018c; IBM 2019d). Slab cutting can be done by either using a specialised saw powered by machinery or by splitting the rock manually using chisels, hammers and wedges (IBM 2018e). In some cases, this process is assisted by explosives (ICN, SCL, Glocal 2017; GIZ 2016; Chinnadurai and Jayamani 2019).

The formal production of limestone in India was estimated at 338.6 million tonnes during 2017 – 18 increased by 7.6% as compared to the previous year. 96% of the total production of limestone goes into cement manufacturing (IBM, 2019d). No substitute is available at present for its use in cement manufacturing. Import dependency would rise from 0% to 20% if no new reserves are identified in the coming 20 years. Recovery/recycling from cement is less a far-off prospect as construction work has a high lock-in period. The calcination of limestone as part of cement manufacturing is one of the largest emitters of CO₂, an industry that accounts for 7% of India’s total CO₂ emissions (IBM 2019d). IBM (IBM 2019d) observes that limestone mines that are vertically integrated into the operation of cement and steel makers are highly mechanised while other mines are only semi-mechanised and rely

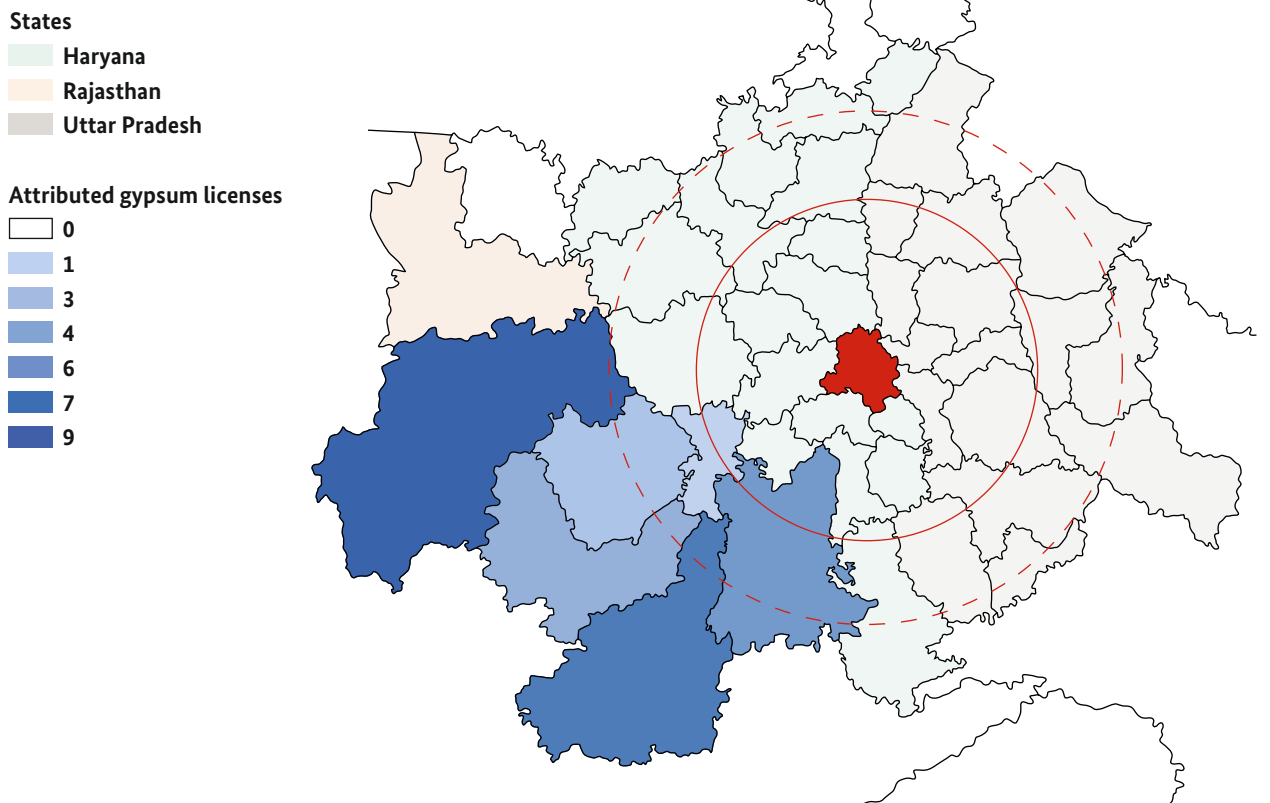
¹⁴ Interview with Prem Mahadevan.

¹⁵ Interview with Prem Mahadevan.

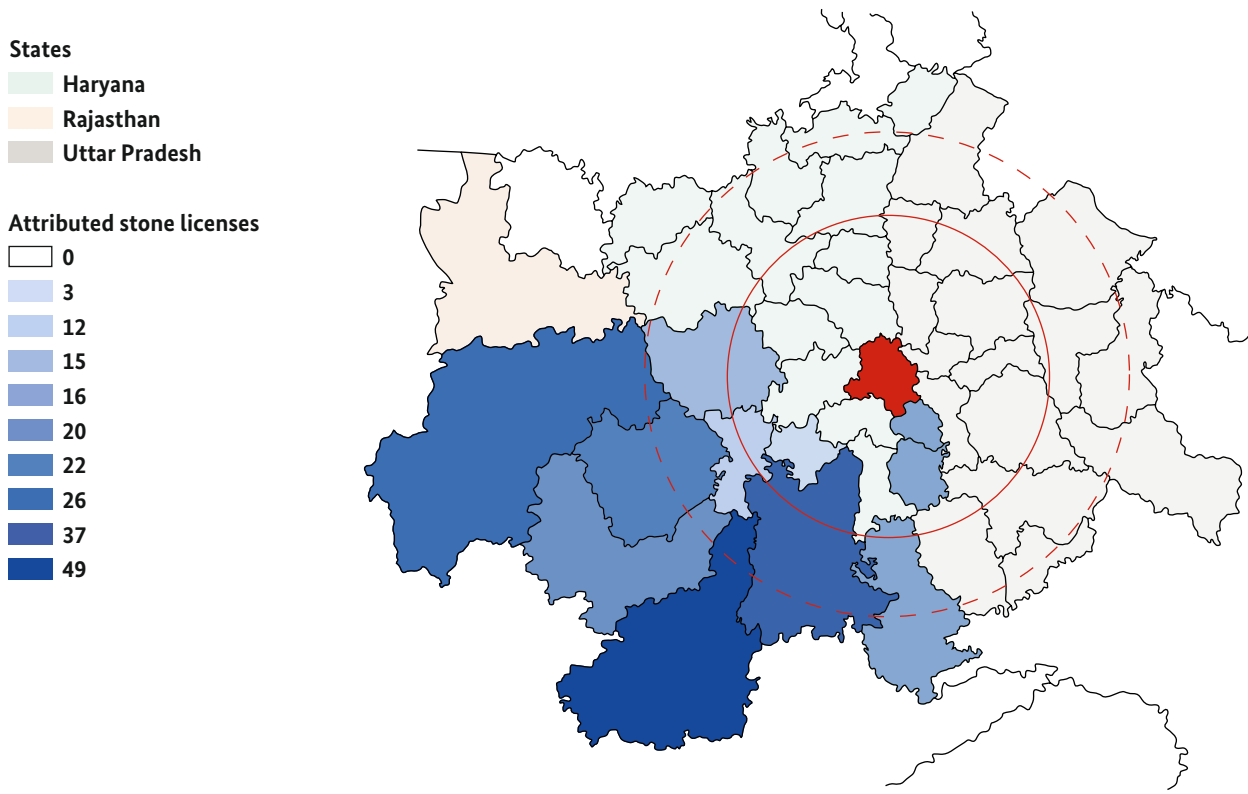
Map 3 – Gypsum licenses per district around Delhi



Map 4 – Limestone licenses per district around Delhi



Map 5 – Stone licenses per district around Delhi



on the same combination of techniques as other rock quarries. Crushing (processing) takes place outside of the mine sites themselves (GIZ 2016), with the exception of some gypsum mines in Rajasthan (IBM 2018a). Prior to the rock cutting process, top soil and overburden are removed to allow direct access to the rock. All these operations generate significant amounts of fine dust.

Mine production of gypsum in India in 2018–2019 was 2,700,000 tonnes as per the Mineral Commodity Summaries 2020 by the U.S Geological Survey. Gypsum is traditionally used in the manufacture of cement, fertilizer (ammonium sulphate) and plaster of Paris. A comparatively new usage of gypsum in India is the making of plasterboard, whose market size is estimated to grow from 18.07 billion USD in 2016 to 23.85 billion USD by 2021, at a CAGR of 5.7% from 2016 to 2021. Gypsum produced from mines represented 58.4% of India’s consumption, while 36.9% originated as a by-product of chemical manufacturing processes, and the remainder 4.7% as by-product of salt pans (IBM 2018a).

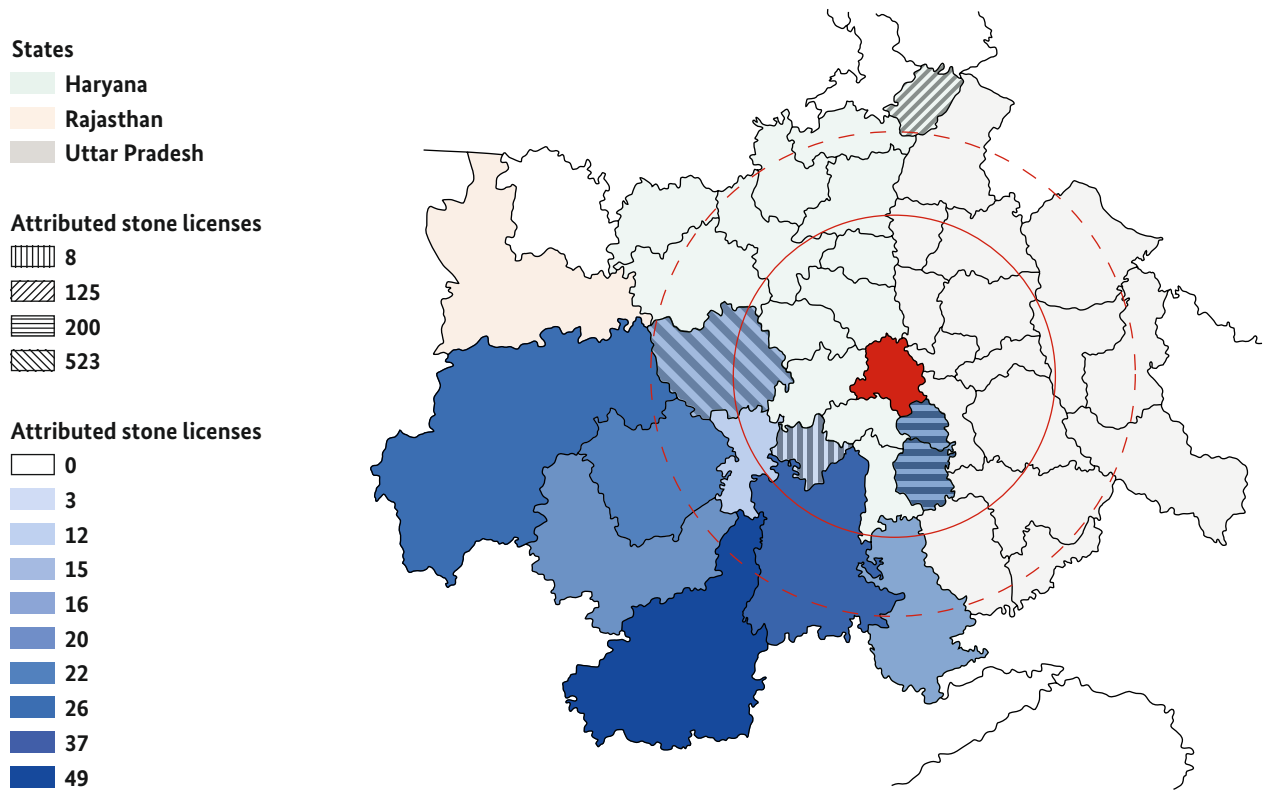
The South Indian (Andhra Pradesh, Karnataka, Telangana) granite sector has been characterised as being highly labour-intensive with most of the quarries being hardly mechanised and depending “upon a large

number of skilled and semi-skilled labourers for carrying out various activities. Jockey drillers, stone cutters, dressing workers, detonators and other skilled and semi-skilled labourers constitute the bottom of the labour pyramid. Out of 22 quarries researched the use of heavy machinery like compressors, drilling machines, and big cranes is observed only in eight quarries” (ICN, SCL, Glocal 2017).

Dimension stones extraction generates substantial rock waste which has is processed into money generating opportunities, such as M-sand in the case of granite, aggregates, or more recently ‘Terrazo’ (stone chips set in cement, epoxy or polyacrylate and then polished) (IBM 2018e; ICN, SCL, Glocal 2017).

The raw processing of waste rock, which breaks this rock into boulders that can be fed into a crusher, is conducted in two different ways. Either the quarry management hires the workers for processing the waste rock or the processing of waste rock is conducted without the involvement of the quarry management. In the latter case, the quarry management dumps the waste rock in a corner of the quarry and allows local people to process and sell the waste rock. Waste rock is processed on a piece-rate basis either by workers that either work for the quarry, are hired by labour contractors or work as a family production

Map 6 – Comparison of rock crushing licenses and formal rock extraction titles around Delhi



unit, complementing the work of the head of the family, or simply are local villagers being granted access to the waste rock (ICN, SCL, Glocal 2017; Interview with K). This waste rock is either processed on site, in a corner of the quarry or brought back home by waste rock labourers (ICN, SCL, Glocal 2017).

Competing land uses. As noted earlier, rock mining requires the removal of topsoil in its areas of operation (IBM, 2019b), making land unfit for future agricultural use. In addition to this direct impact, rock extraction also generates dust and impacts local aquifers, which also impacts local livelihoods. Competition for land access issues are compounded by lack of clarity in regards to land ownership in rural communities and public land ownership (Dow to earth 2019) and the predominant ownership of small plots which creates a multiplicity of actors.¹⁶ According to stakeholders consulted in Rajasthan by the experts during a prior field visit for another project, the opening of a mine tends to add value to neighbouring plots in the short term, which often heightens local tensions regarding land ownership.

Groundwater depletion. Local communities have been quoted in reporting regularly the lowering of the water table caused by rock extraction (Dow to earth 2019; Reuters 2018).

Impact of dust on flora. The high levels of dust generated by rock extraction can also have an impact on agricultural livelihoods. Dust covers leaves which lowers their capacity to photosynthesize and thus grow, lowers their protein production, and renders crops more sensible to insect depredation, thereby impacting both plant growth and potentially local nutrition (Saha and Padhy 2011).

Modification of landscape. Rock extraction modifies the physical landscape through the removal of vast quantities of rock, as illustrated by the disappearance of a quarter of the hills forming the Aravalli in parts of Alwar District (Rajasthan) (Times of India 2018; DNA India 2018). The establishment of roads to access remote quarries could potentially lead to higher levels of human occupation and thus impact on forested areas.¹⁷ These impacts to the landscape can also further

¹⁶ Interview with Kuntala Lahiri-Dutt.

¹⁷ For further details on these indirect impacts of mining refer to: The World Bank. 2019. "Forest-Smart Mining: Artisanal & Small-Scale Mining in Forest Landscapes."

expose Delhi NCT to the impacts of climate change. Among others the levelling of sections of the Aravallis has exposed the city to sand blowing from the Thar Desert (Down to earth 2019; Reuters 2018).

Impact on fauna. In addition to the wide scale impacts observed in the Aravallis and its biodiversity (Down to Earth 2019) rock extraction has been noted as having taken place inside conservation areas such as the Sariska Tiger Reserve and Jamwa Ramgarh Wildlife Sanctuary (Environmental Investigation Agency 2003). Despite this reporting being more than 15 years old, given the absence of notable enforcement efforts these issues are likely still current.

Forced labour is common in rock quarries and is a product of debt bondage and linked to the use of labour brokers to supply mine-sites with labour while simultaneously outsourcing their social obligations towards the workers (ICN, SCL, Glocal 2017). Typically, labourers are paid on a piece rate basis whether they work on extraction or raw material processing. In Southern India's granite quarries the average daily income from piece work has been noted as being under the legal minimum wage rates prescribed for similar workers (ICN, SCL, Glocal 2017). In Rajasthan it was noted men can earn the local minimum wage for mining areas (around 300 Rupee at the time, or 3.5 Euro with current exchange rates) but that women and children typically earn much less (120 – 200 Rupee at the time) as they cannot perform the more physically demanding work (Aravali 2018). These meagre incomes reinforce issues of bonded labour and encourage the use of family members to bolster household income. Work as a family production unit is a confirmed driver of the worst forms of child labour,¹⁸ whether it takes place on the quarries or at home (Praxis and Partners in Change 2017; ICN, SCL, Glocal 2017). Labour bondage in Rajasthan quarries is characterised by debt bondage created by salary advances and there are recorded cases where debt is passed on to the next of kin after the labourer is no longer able to perform his work, in particular in cases of occupational induced silicosis. And while on paper a comprehensive array of legislation and policies exists to prevent forced labour and rescue bonded labourers, in practice these are not effective and/or implemented due to a lack of resources and /or political will. Despite lack of resources, 1,845 labourers,

including 611 children, were rescued from quarries between 2004 and 2016, illustrating the extent of the problem (Praxis and Partners in Change 2017).

Worst forms of child labour. The rock extraction sector is characterised by substantial levels of child labour. According to a UNICEF sampling of two Rajasthan sandstone mining localities (adjacent to but not part of the area of supply), 38% of children sampled had worked in rock quarries. Aravali (2018) estimates that as many as 375,000 children work in/with quarries in Rajasthan. These children are driven to do so due to the high levels of poverty and lack of alternatives in their localities (Praxis and Partners in Change 2017) as well as dissatisfaction with the schooling opportunities (Aravali 2018). Children are particularly likely to be involved in the raw processing of rock as they are not able to undertake the more physically demanding tasks in the quarry and due to the “lighter” nature of their work are paid less and earn less than the legal minimum wage (ICN, SCL, Glocal 2017).

Occupational health and safety. Work on the quarries is as a rule conducted with no PPE and accidents are common, sometimes resulting in the death of workers (Delve 2019; GIZ 2016). Most accidents go unrecorded, but Aravali (2018) reports estimates of around 460 known deaths in 2005 in Rajasthan. Increased mechanisation of quarries coupled with lax oversight and an untrained workforce could result in higher risks to workers rather than decreasing them (GIZ 2016).

Impacts on health are noted as being pervasive and include respiratory ailments such as coughing, shortness of breath, chest pain, silicosis, asthma, bronchitis as well as skin illnesses, temporary and permanent hearing or eyesight loss (GIZ 2016; ICN, SCL, Glocal 2017). Silicosis, a lung-illness caused by the inhalation of dust containing silica, is noted as the most salient health issue at the mining stage (Praxis and Partners in Change 2017) with studies conducted in Rajasthan showing that 50 to 75% of mineworkers are impacted (Sharma 2015). Silicosis is irreversible and impacts the physical wellbeing of workers, and thus their long-term livelihood-earning capacity, and can lead to a premature and painful death.

As for the cases of forced labour and the worst forms of child labour, a significant array of regulations exists in Rajasthan to address OHS gaps, but in practice these are not implemented to a significant extent due to lack of resources and/or interest (Praxis and Part-

¹⁸ According to an interview with Kuntala Lahiri-Dutt.

ners in Change 2017). The use of labour contractor allows mining operators to distance themselves from OHS obligations towards the labourers on their quarries (ICN, SCL, Glocal 2017). And while “*India’s strong tradition of trade unions could help support worker’s rights and improve labor conditions, due to the sector being largely confined to the informal economy, there are no significant independent unions or associations representing the rights and advocating on behalf of miners*” (Delve 2019).

Corruption and bribery are reported as routine by both NGO and media and one of the reasons behind the lack of oversight of extraction areas, in combination with lack of resources. In addition to bribes paid to local civil servants, the involvement of Politically Exposed Persons (PEPs) is noted (Tehelka 2012), refer to the sub-section on sand for the involvement of construction companies. The involvement of PEPs in the mining business is facilitated by the existing mining subcontracting practices, where a mine license owner subcontracts a third party to mine on its behalf or rents the title to a third party¹⁹.

Misdeclaration of origin of minerals occurs routinely for rocks until they are processed, at which time they are “legalised”²⁰. See section 3.2.5. on transport and trading for details.

Violence or threats thereof. Refer to the sub-section on sand for details.

Gender and discrimination. As noted earlier, gender repartition of roles is the norm in less mechanised mines, with women only having access to the less strenuous but less paying jobs (India Committee of the Netherlands 2010). As for children, women’s work in the quarries clusters around the raw processing of waste rock, activities that pay less than more physically intensive quarry work. Women tend to either be from the area of mining or migrants that have travelled with their families (ICN, SCL, Glocal 2017). As the Mining Act of 1952 forbids women to work in mines underground and at night, women are not able to find better paying jobs in the larger, more mechanised mines (Delve 2019). No specific information on sexual violence in quarries was available at the time of research.

Generally, there is a higher percentage of migrant labour in rock quarries than in the Indian economy at large (Chinnadurai and Jayamani 2019), although use of migrant labour seems to be more important in mines requiring a bigger workforce (ICN, SCL, Glocal 2017). Migrant workers predominantly perform semi-skilled or unskilled work and are noted as being preferred by owners for certain activities (machine operation, rock cutting, breaking and dressing, blasting) as they are found to be more obedient and work flexible and longer hours as they often have fewer social or family commitments, and as they are often paid lower wages (Chinnadurai and Jayamani 2019; ICN, SCL, Glocal 2017). The seasonal nature of the work further entrenches the use of labour brokers and the associated risks. Migrant workers are usually denied access to social security entitlements and basic health facilities because they often do not possess the documents needed to establish their identity and claim support (Sharma 2015). The majority of the labourers toiling in quarries originate from vulnerable populations. In Rajasthan it is estimated that 95% of workers are Scheduled Castes and Scheduled Tribes (SCST) (Aravali 2018), in Southern India the SCST make up 38% of the labour force while 43% are classified as Other Backward Class (OBCs) particularly from one community called Vaddera.

Due to the listed issues being prevalent across the sand and rock sectors, relations between the extractive sector and civil society are often strained and public opposition to mining is pronounced, particularly in urban centric media reporting. This type of reporting contributes to building a non-nuanced blanket anti-mining narrative, especially as it does not make clear distinctions between LSM and ASM or formal and informal forms of mining. This lack of nuance has both strengthened the divergence of priorities between the Federal and the State levels and has led to these different forms of mining to coalesce into important power groups in extraction areas, groups that are supported by the construction industry, one of India’s richest and most politically connected industries.

¹⁹ Interviews with Kuntala Lahiri-Dutt. Also see Chinnadurai and Jayamani, 2019.

²⁰ Interview with Thangaperumal Ponpandi.

3.2.3. PROCESSING

CLAY

No processing step could be identified in the case of the use of brick clay. Clay is extracted and then used as a raw input in the manufacture of bricks.

SAND

With the exception of the washing and screening of sand extracted from non-alluvial deposits, no processing step could be identified in the case of sand. This initial processing is enmeshed into the extraction operations and related issues are addressed in said section.

ROCKS

Processing of rocks involves crushing the material into the appropriate size, from aggregates to powder size. In addition to the crushing process limestone and gypsum can be calcinated in kilns as part of their processing. In line with a media and NGO focus on impacted communities and materials for export, significantly less information is available about this stage of the supply chain than about the extraction stage.

Gypsum and limestone

Production of lime requires the calcination of limestone in kilns at a temperature of up to 1,200°C. The process releases the CO₂ present in limestone to produce ‘quicklime’ (CaO) in the form of hard white lumps (IBM 2019d). When slaked with water and mixed with sand, quicklime forms mortar and plaster. Specific information on the internal processing of limestone and gypsum in cement and steel plants in India is not publicly available. Given its integration into fully formal ventures, issues mentioned in the reviewed material are limited to CO₂ emissions.

CO₂ emissions. Limestone calcination produces substantial amounts of CO₂. Limestone calcination was

estimated to represent a release of 137 million tonnes of CO₂, approximately equivalent to 7% of Indian total man-made CO₂ emissions (Maity et al. 2015).

Crushed rock

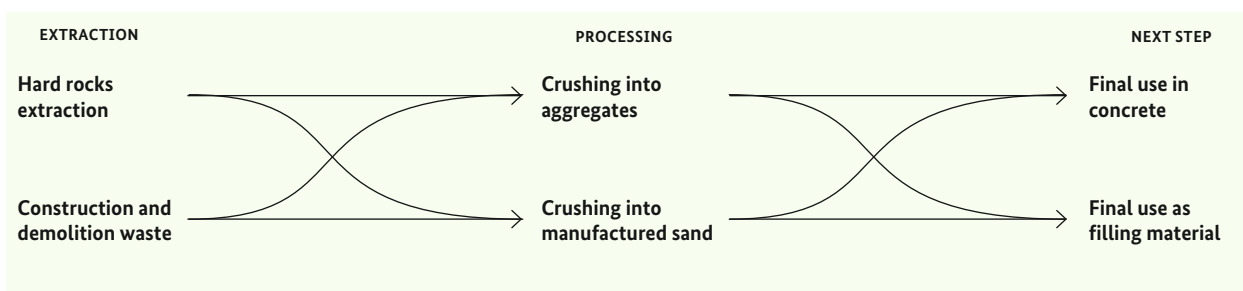
Rocks processed into aggregates can be used as ballast for train tracks, as macadam pavement, or *terra-zo*, but their main use remains in the manufacture of concrete (and by extension concrete blocks) and as a filler material in the construction of roads (GIZ 2016).

Based on data from Haryana’s Mines and Geology department 856 rock crushers licences have been awarded in the area of supply,²¹ similar information could not be obtained for Rajasthan and Uttar Pradesh. Rock crushing units form clusters in proximity to areas of rock extraction, their markets, and highways in order to diminish transportation costs (Sivacoumar et al. 2006). Crushing of rocks into aggregates is a labour-intensive small-scale industry depending largely on migrant and unskilled labourers. The activity offers a seasonal employment alternative for agricultural workers. According to Delve (2019), the rock crushing sector alone was estimated to provide direct employment to over 500,000 people in 2012 and to have an annual turnover of over 1 billion USD.

Systematic delays in the submission of grants for the renewal of rock crusher licenses in Haryana, of up to 650 days (CAG 2019) suggest that oversight over this node of the supply chain is as limited as at the extraction level and that activities are still unorganised at this stage.

²¹ More specifically 523 in Bhiwani, 200 in Faridabad, 8 in Rewari, 125 in Yamuna Nagar. See <http://minesharyana.gov.in/en/mineral-concession/stone-crusher>, as accessed on 01.06.2020.

Figure 9 – Rock processing and associated steps



Rocks that arrive at a rock crushing unit are first manually broken into smaller pieces if required, then fed into jaw crushers, and screened by vibratory or rotary screens into different sizes. Dust and solid waste are removed prior to their packaging and loading onto trucks (Saha and Padhy 2011). Rocks are usually ground from a size of 200–300 mm into smaller pieces more adapted to the needs of the construction industry, generally 6, 12, or 25 mm (Sivacoumar et al. 2006).

According to The Energy and Resources Institute (TERI) the Ministry of Micro, Small & Medium Enterprises (MoMSME) is working with State agencies and industry clusters in targeted sectors, which does not include construction suppliers, to support them in the adoption and mainstreaming of energy efficient practices²². This takes the form of training as well as fiscal incentives.

While only very limited information is available at the rock crusher level the following risks have been highlighted in the collected literature.

Groundwater pollution, due to metal leaching, can occur in crushed rock waste dumps or in the rare cases where aspersion is used as a dust suppressing method (Sheikh et al. 2011).

Impact on biodiversity and the landscape. According to activists the presence of these rock crushing clusters creates strong demand for materials at the local level. They are thus an integral part of the pull factors leading to illegal rock extraction both in their districts and in neighbouring districts (Times of India 2018; Down to earth 2019a).

Impact of dust on flora. The high levels of dust generated by rock crushing can impact local crops. Refer to the sub-section in the rock extraction section under 3.2.2. for further details.

Forced labour. While no recent (since 2000) mention of bonded labour could be found, it remains that the reliance of the sector on migrant labour suggest the participation of labour brokers which represents a significant risk of debt bondage for labourers, as illustrated in the rock extraction section under 3.2.2. Limited oversight by authorities heightens that risk.

Occupational health and safety and community health. Seasonality, high turnover, asymmetric power positions and lack of OHS knowledge among workers has resulted in the high risk exposure of workers, dependents and local communities through the location and design of rock crushing sites and their processes, lack of PPE for workers and social attitudes towards OHS. Studies conducted in Orissa (Amitshreeya and Panda 2011), West Bengal (Saha and Padhy 2011), Uttar Pradesh (Sheikh et al. 2011), and Tamil Nadu (Sivacoumar et al. 2006), have all reported elevated levels of dust in the air with measures both within the industrial operations and in neighbouring residential areas, levels that exceed limits set for industrial operations, let alone residential areas. Impacts on health are noted as being pervasive and include respiratory ailments (coughing, shortness of breath, chest pain, asthma, bronchitis (Sheikh et al. 2011), skin diseases, temporary and permanent hearing loss, and accidents. As at the extraction level, silicosis is the main risk for labourers at the rock processing stage.

Misdeclaration of origin of minerals. The processing stage offers an opportunity for the legalisation of illegally procured material.²³ Applications for a rock crushing license do not require to list the origin of the rocks to be sourced and there is no monitoring of the origin of the processed material (CAG 2019).

Gender and discrimination. Migrant workers are usually denied access to social security entitlements and basic health facilities because they often do not possess the documents needed to establish their identity and claim support (Sharma 2015). Women working on site can often be forced to leave children close-by due to the lack of day-care options, leaving them exposed to dust (Sheikh et al. 2011). This issue is likely to be more pronounced for migrant women, who cannot count on a family network to look after their children.

CO₂ emissions. The production of aggregates from rock produce significant amounts of CO₂. It is estimated that about 20 kg of CO₂ is emitted during the quarrying, crushing and transport stages of 1,000 kg of rock into aggregates (GIZ 2016).

²² Interview with Sanjay Seth, Megha Behal, and Ankita Bokhad.

²³ Interview with Thangaperumal Ponpandi.

3.2.4. MANUFACTURING

As stated in the processing section MoMSME is working with State agencies and industry clusters in targeted sectors, not including construction suppliers, to support them in the adoption and mainstreaming of energy efficient practices.

CLAY AND BRICKS

Clay brick manufacturing takes place from October to May (Praxis and Partners in Change 2017) in clusters located 0.5 km to 5 km from the site of clay extraction to minimize transportation costs (GIZ 2016). These clusters are located outside of the cities and in the outskirts of small towns.²⁴

Once clay arrives at the brick kiln it is mixed with the material added by this specific kiln (this can include: sand, lime, magnesia, iron oxide, straw, among others). The manufacture of construction materials is extremely cost conscious and materials that become too expensive due to transportation costs are replaced with locally available materials.²⁵ Bricks are then formed with this material and are put into a kiln to be fired. Once this process is completed they are either stored on site or transported directly to end users (Praxis and Partners in Change 2017; Anti-slavery 2015).

Brick manufacturing is one of the biggest employers of migrant labour, with more than 10 million labourers (Chinnadurai and Jayamani 2019) in the estimated more than 140,000 kilns operating in the country

(GIZ 2016). The National Sample Survey Organisation estimated that in 2009 – 2010, brick kilns employed around 23 million labourers in total (Anti-slavery 2015).

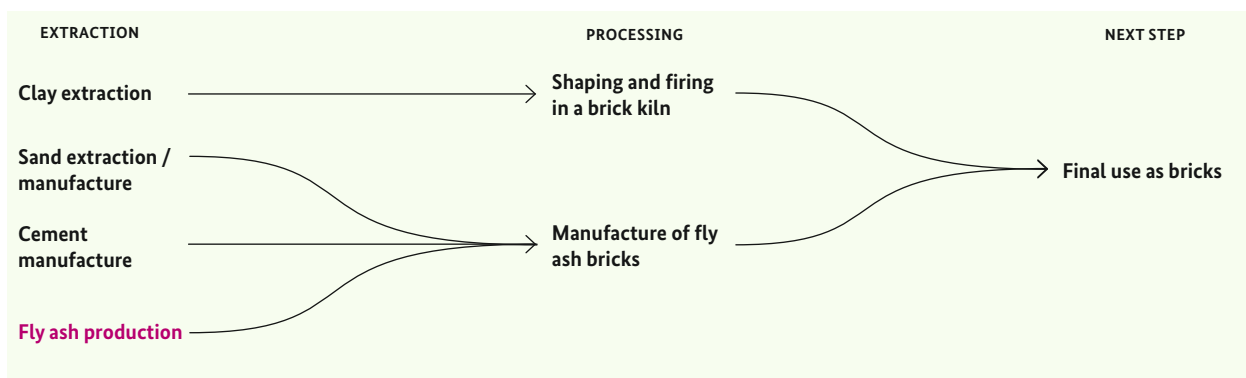
The sector is characterised by its unorganised nature. Brick kilns are not visited by civil servants as a rule and implementation of legal requisites is often non-existent:

- ▶ Praxis and Partners in Change (2017) note that during a visit of the National Commission for Protection of Child Rights in 2013, of the 300 brick kilns functioning in Bhilwara, only 45 were registered with the district administration. The Commission’s representatives were also surprised by the district administration’s indifference to the issue.
- ▶ Anti-slavery (2015) notes that: *“In order to ensure minimum wages are paid, the Labour Department must inspect worksites. Although India has ratified ILO Convention 81 on labour inspections and there is domestic law in place regarding this, in practice, Anti-Slavery International and its partners have found that very few brick kilns are inspected. Almost all brick kilns fail to keep employment records, meaning that it is impossible to determine what workers are being paid.”*

In contrast to this unorganised sector the manufacture of fly ash bricks has emerged as a growing sector following efforts from the Government of India to promote the use of secondary raw materials in the construction sector by introducing the Fly Ash Notification (S.O. 763 (E)) issued by MoEF&CC in 1999 (amended in 2003, 2007, 2009) which promotes the utilisation of fly ash, a waste-product of coal burning,

²⁴ Interviews with Dr Gurdeep Singh and Vikash Nayak.
²⁵ Interview with Pradip Chopra.

Figure 10 – Brick manufacture and associated steps (in pink are elements whose production is not covered in this report)



in place of soil. This notification “mandates the use of fly ash in building materials for construction projects falling within a 100 km radius of coal or lignite based thermal power plants. The subsequent amendments to this notification directed builders to use at least 25% of fly ash in clay bricks and 50% of fly ash by weight in fly ash bricks, blocks, etc. [...] It also stipulates that thermal power plants should provide at least 20% of dry fly ash free of charge to units manufacturing fly ash or clay fly ash bricks, blocks and tiles on a priority basis over other users. [...] If the manufacturing unit is within a radius of 100 km, the cost of transportation of fly ash to the manufacturing site should be borne by the power plant. Beyond that, the cost shall be borne equally by the manufacturers and the thermal power plants” (GIZ 2016). Fly ash bricks show better resistance than traditional clay bricks according to certain stakeholders,²⁶ although others disagree²⁷ and can be used for the same purposes. The promotion of fly ash bricks serves the double objective of lessening the exploitation of soil deposits, and thus of arable land, and to dispose safely and beneficially of a polluting waste-product.²⁸

As only fully formalised operations are able to work with coal plants this sector is characterised by full formalisation and the use of modern machinery. To benefit from these advantages fly-ash brick plants have been established in proximity to power stations, often sandwiched between a power plant supplying them with fly ash and their market.²⁹ This makes manufacturing plants dependent on specific energy plants for a constant fly ash supply. Would one of these plants close it is not certain that the corresponding manufacturing plants would find it commercially viable to source fly ash from an electric plant further afield.³⁰

No reporting on conditions in fly ash bricks plants has been identified. The clay brick sector on the other hand has been extensively reported on, including in Rajasthan, and has shown to exhibit the following challenges.

CO₂ emissions from brick kilns are significant, coupled to other harmful emissions (carbon monoxide, sulphur dioxide, nitrogen oxides (NOx) and suspended particulate matter) as brick kilns are coal fired. The

Central Pollution Control Board calculates the emissions of the estimated 140,000 brick kilns in the country to be about 66 million tonnes of CO₂ (GIZ 2016).

Impact of dust on flora. The air pollution and bottom ash generated by these kilns cause damage to property and crops (GIZ 2016), especially as these kilns are located in close proximity to their source of soil, often agricultural land.

Forced labour is ubiquitous in brick kilns due to low cost of bricks and relatively high cost of production (GIZ 2016) and takes the form of “the employment of a workforce that has predominantly migrated internally, the majority whom are from socially excluded and economically marginalised communities,, the widespread use of large advances and loans to secure and control workers, exploitative recruitment practices, and a piece rate wage system which treats the entire family as the wage unit rather than each individual worker therefore resulting in extremely low wages. This is combined with a failure by the Government to implement relevant laws and prosecute offenders” (Anti-slavery 2015). It is estimated that a couple making 4,000 bricks over the course of 2 days of back breaking labour will earn Rupee 250 (approx. 3 Euro) or Rupee 125 per day for the two of them (Praxis and Partners in Change 2017). Labour bondage in Rajasthan quarries is characterised by debt bondage created by salary advances, and while on paper a comprehensive array of legislation and policies exist to prevent forced labour and rescue bonded labourers, in practice these are not effective and/or implemented due to a lack of resources and /or interest (Praxis and Partners in Change 2017; Anti-slavery 2015). It is estimated that Rajasthan had more than 300,000 bonded labourers in brick kilns in 2014 (Praxis and Partners in Change 2017).

Worst forms of child labour. Given the aforementioned use of families as production units and their migration from other parts of the country, the presence of children on brick kilns is endemic. When present on the sites said children do not attend school and work alongside their parents to achieve higher production and thus higher incomes. Children can be seen working in all activities of the manufacturing process, although only the older children will do the most demanding physical labour such as loading trucks and transporting bricks (Praxis and Partners in Change 2017; Anti-slavery 2015). As for forced labour, while on paper a comprehensive array of legislation and policies exist to prevent forced labour and rescue bonded labourers in Rajasthan, in practice these

²⁶ Interview with Dr. Gurdeep Singh and Vikash Nayak.

²⁷ Interview with Pradip Chopra.

²⁸ Interview with Vikash Nayak.

²⁹ Interview with Vikash Nayak.

³⁰ Interview with Sanjay Seth, Megha Behal, and Ankita Bokhad.

are not effective and/or implemented due to a lack of resources and /or interest (Praxis and Partners in Change 2017; Anti-slavery 2015). According to Anti-slavery (2015) Anganwadi (nursery services) workers, as well as other relevant welfare officers such as health officers, refuse to visit brick kilns.

Occupational health and safety and living conditions in brick kilns are harsh. The average working day is 15 to 16 hours long and includes intense physical activity likely to result in long term debilitating injuries (Anti-slavery 2015; GIZ 2016), back or knee pain caused by truck loading for example. Accidents such as injuries from brick falls and burns are common (Praxis and Partners in Change 2017). Despite exposure to the air pollution and bottom ash generated by the kilns, labourers are not issued any form of PPE, leading to health issues, especially respiratory illnesses (GIZ 2016). Furthermore as workers live on site, they are also exposed to sub-par living conditions characterised by high levels of hazardous substances such as arsenic, burnt plastic and dust, overcrowded makeshift accommodation, limited access to drinking water and extremely limited or non-existent provision of toilet facilities, if present these are not gender appropriate (Anti-slavery 2015; Praxis and Partners in Change 2017). As for the cases of forced labour and the worst forms of child labour, a significant array of regulations exists in Rajasthan to address OHS gaps, but in practice these are not implemented to a significant extent due to lack of resources and/or interest (Praxis and Partners in Change 2017).

Corruption and bribery seemingly enables the functioning of the sector in its current conditions. Anti-slavery (2015) notes that poor enforcement of laws and prosecution of the operators exploiting bonded labourers is potentially linked to these operators belonging to powerful local elites; interviewed stakeholders confirm the significant, albeit disorganised, local political leverage of kiln owners.³¹

Despite operating formally, fly-ash brick manufacturing plants may also experience the impacts of corruption as issues of fly-ash supply from thermal power plants have emerged despite wide availability of the waste-product. Shift in availability may “range from fly ash being sold at higher rates to cement manufacturers to halt in supply during inspections or visits at thermal

power plants, and giving priority to road or other project contractors owing to ‘election compulsions’” (Down to earth 2019b). Oversupply of fly ash has been noted as an ongoing problem (Newsclick 2020).

Violence or threats thereof is directed towards workers and their families, in particular towards workers and their families seeking out help to escape their conditions of forced labourers. Women are also vulnerable to abuse and sexual violence (Praxis and Partners in Change 2017; Anti-slavery 2015). Stakeholders that have sought to organise to demand minimum wages, improved working conditions, or to protest against abuse, also report violence and threats from operators (Anti-slavery 2015).

Gender and discrimination. While the gendered aspects of work on a kiln seem to be limited as pay is based on production, the fact that the contracting of the work is done with the male head of the households means that women and children working as part of the family production unit are not recognised as workers and do not receive any pay directly (Anti-slavery 2015), putting them in a situation of additional vulnerability.

Caste and migration-based discrimination is rampant as brick kiln migrant workers are predominantly from the poorer states in the country and are in the majority of cases SCST, making them vulnerable to exploitation (Anti-slavery 2015).

SAND

There is no independent sand specific process at the manufacturing stage. Relevant processes are included in the manufacture of cement or in the production of concrete (see section on end usage under 3.2.6.).

LIMESTONE AND GYPSUM

Based on data from IBM for the 2013–2016 period (IBM 2018a), 99.4% of India’s gypsum consumption happens in the cement manufacturing sector and 0.15% in the manufacture of plaster of Paris. The remainder is used in the manufacturing of asbestos products, ceramics, fertilizer, refractories, textiles, pharmaceutical products and paint. This data however seems to run contrary to IBM’s claim, in the same source, that: “Cement, fertilizer (ammonium sulphate) and plaster of Paris are the three important industries in which gypsum is utilised” (IBM 2018a), as well as comments by an interviewed expert that all drywall consumption in the Indian construction sector is provid-

³¹ Interviews with Kuntala Lahiri-Dutt, and, Sanjay Seth, Megha Behal, and Ankita Bokhad.

ed for by the local industry.³² Given the limited use of gypsum in both the manufacture of plaster of Paris, 0.15% of India’s gypsum usage (IBM 2018a), and the manufacture of drywall, the manufacturing processes for these materials are not presented in this report.

According to IBM figures (IBM 2019d) 97% of limestone is of cement grade and 3% of other grades. Of this 94% was used in cement manufacturing, 4% in iron and steel manufacturing, and 2% in chemical applications in 2017 – 2018. This data however seems to run somewhat contrary to IBM’s claim, in the same source, that: *“The principal use of limestone is in the Cement Industry. Other important uses are as raw material in the manufacture of quicklime (calcium oxide), slaked lime (calcium hydroxide) and mortar. Pulverised limestone is used as a soil conditioner to neutralise acidic soils (agricultural lime). It is used in sculptures because of its suitability for carving. It is often found in medicines and cosmetics. In some circumstances, limestone is used for glass making. As a reagent in fuel-gas desulphurisation, it reacts with sulphur dioxide which enables air pollution control. It can suppress methane explosions in underground coal mines. It is added to toothpaste, paper, plastic, paint, tiles and other materials as both white pigment and cheap filler.”*

Information from IBM (IBM 2019d; IBM 2018a; IBM 2018c) suggest that limestone and gypsum material are either extracted from mines vertically integrated within the operations of cement or steel manufacturing plants or sent directly from third party mine-sites to steel or cement making plants. At the time of writing the supply routes for gypsum and limestone used

in other industries are unknown. Visual information from the National Centre for Safety of Heritage Structures (IIT Madras)³³ suggest the existence of numerous small-scale, likely unorganised, kilns. These are powered by coal and no PPE or OHS measures are visible. Labour conditions would appear to be similar to those in rock crushing operations

CEMENT

The Government of India has undertaken a number of efforts to foster the adoption of alternatives to Portland cement, this includes the update of the National Building Code of India (NBCI) to allow for the use of slag, fly ash, and crushed over-burnt bricks and tiles in plain cement concrete as an alternative to sand/rock aggregate. NBCI also encourages the use of fly ash and ground granulated blast furnace slag as part replacement of ordinary Portland cement in plain as well as reinforced cement concrete. In addition, applicable BIS standards have been revised to support these efforts (MOEFCC 2016).

For a description of the processes involved in the manufacture of cement refer to section 3.1 on cement.

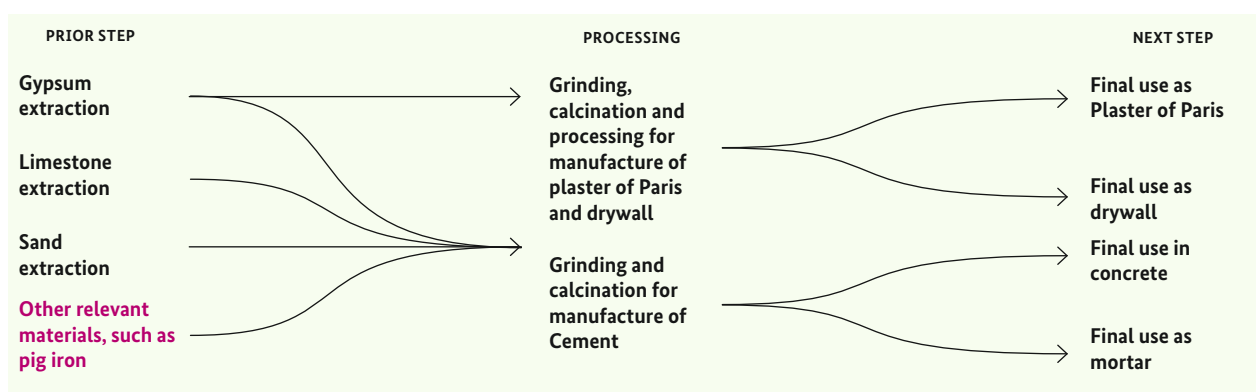
Given the more limited attention the manufacture of cement receives in media, academic, and NGO reporting, no overall information on the manufacture of this commodity and its impacts could be found. Neither did industry information prove to be relevant.

At most it can be said that based on IBM information (IBM 2018b) that, as mentioned previously, plants are

³² Interview with Pradip Chopra.

³³ Available via <http://www.ncshs.org/events/workshop/lectures/2.%20Lime%20Burning%20in%20India.pdf>, as accessed on 02.06.2020.

Figure 11 – Cement manufacture and associated steps (in pink are elements whose production is not covered in this report)



typically located next to limestone extraction sites to limit transportation costs. Furthermore, due to coal being the key source of energy for cement companies the industry also generates substantial amounts of fly ash which can then be used in the manufacture of fly ash bricks.

3.2.5. TRADING AND TRANSPORTING

Transport of materials taking place predominantly by road **CO₂ emissions** from trucking are a concern shared by all materials. However, the complete lack of information on the amount of such trucks, the length and number of their travels, the average dryness of their load, and other factors make the calculation of associated CO₂ emissions an impossibility within the scope of this research.

In Haryana, Rajasthan, and Uttar Pradesh transport of minor minerals requires a booklet issued by the State's authorities to accompany the cargo. In Rajasthan and Uttar Pradesh this process is done online while in Haryana it is done offline (MoM 2018; CAG 2019). These booklets contain numbered mineral transit passes containing the relevant information (source of dispatch, registration number of the vehicle, weight of mineral or quantity of mineral dispatched, name of the transporter and destination of the consignment). Conversely mineral concession holders need to maintain a register of all receipts and dispatches along with the particulars of the mineral transit passes issued. A complete account of the booklets of mineral transit passes should be maintained by the license holders and mineral transit passes should be presented upon demand from an authorized officer (CAG 2019). But, as CAG (2019) highlights, spot checks from Haryana agencies are limited and are not recorded.

CLAY AND CLAY BRICKS

Transport takes place between the extraction site and the brick kiln, and, later between the kiln and the construction site. Whether the trucks belong to the brick kiln owner or are contracted is unclear at this stage, as are the transport distances.

There is no physical marketplace for bricks, these are traded by intermediaries who represent a number of brick kilns and essentially act as a marketer and broker. These intermediaries do not ensure quality con-

trol and can have a broad client address book.³⁴ The seller is paid after reception of the bricks.³⁵

Transport to the construction site is paid for by the seller and bricks are transported by a contracted third party.³⁶ These transport service providers are small to mid-size players with up to 20–30 trucks. Breakage of bricks during transport creates some level of waste, breakage of fly ash bricks is noted as being much more rare.³⁷

SAND

Transport takes place between the extraction site and either a storage area or a user such as a cement manufacturing plant or a construction site where it is mixed with cement and coarser aggregates if required to produce concrete and mortar, or is used as a filler, for example in the construction of roads (Rege 2015; MOEFCC 2016). Based on secondary information the typical transport distance could not be quantified at the time of writing³⁸.

Transporters are usually contractors and mining companies, although there are reports of enterprising village youths ferrying sand in private vehicles (GITOC 2019). In certain cases alluvial extraction requires the construction of temporary roads and bridges to allow for the transport of sand (Rege 2015). At this stage the exact relationship between daytime large scale extraction and night time large scale extraction and their transporters is not yet clear. Rege (2015) notes that operators can range from sizeable legal companies with in-house transport to *several small-time independent "contractors"* (including transporters) that can loosely coordinate their operation or be managed by a single person operating as a manager.

If required, sand can be stored for varying time periods, for example to take advantage of high sand prices during the monsoon season. This storage can take place on private plots either belonging to the operator, to legitimate sand mining companies, or to locals. Locals are generally compensated but there are cases in

³⁴ Interview with Vikash Nayak.

³⁵ Interview with Pradip Chopra.

³⁶ Interview with Pradip Chopra.

³⁷ Interview with Vikash Nayak.

³⁸ Note that due to centrality of transport as a cost factor it might be possible to estimate the maximum commercially viable distance for sand suppliers once transport costs are known.

which land has been forcibly occupied to store sand, including public land (Rege 2015).

Based on the available information, there is no known physical marketplace for sand. Intermediaries, either companies or individuals, connect sand extraction sites and sand users. Based on the (limited) information currently available there does not seem to be signs of vertical integration between the construction sector and sand operators.³⁹

Not only do sand prices vary nation-wide according to proximity of supply and associated transport costs, it can also vary seasonally when monsoon, temporary mining bans related to the monsoon, or blanket bans constrain the extraction (MoM 2018; GIZ 2016). Despite these variations the sand price from illicit sources is noted as being nearly half as expensive as sand from legitimate sources due to its reduced operational costs, even when factoring in the required bribes (GITOC 2019), an important element for an industry as cost-conscious as construction. Constricted supply and high prices have been noted to lead to the mixing of low quality sand with usable sand. Consumers are generally not aware of low quality sand which is not suitable for construction and could lead to structural failure in buildings (MoM 2018).

Despite broad trends observed – such as by GITOC (2019): *“Prices increase approximately four-fold from the time of extraction to the point of selling. This is due to the cost of transportation and storage, as well as bribes paid to local police and administration officials”* – it is not clear whether this price change is reflected in the pay of the miners.

Corruption is often required to transport sand to the final users as the use of booklet is limited. According to the MoM (2018) the majority of the registered illegal mining cases are related to the illegal transportation of sand. Rege (2015) notes the existence of different types of corruption practices to avoid controls:

- ▶ Bribes can be paid at each checkpoint;
- ▶ A single bribe per loaded truck can be paid, the truck is assigned a code number and will no longer be stopped on route; or

- ▶ A monthly fee is paid and the truck is free to move as many loads as desired during that lapse of time.

Modification of landscape can happen when temporary roads and bridges are constructed to facilitate the transport of sand illegally extracted⁴⁰ (Rege 2015; The Tribune 2019). The impacts created by this temporary infrastructure are presented in the sand-extraction section under 3.2.2.

LIMESTONE AND GYPSUM

Given the more limited attention the extraction, trade, and processing of limestone and gypsum receives in media, academic, and NGO reporting no overall information on the transport of these commodities from the mines to the enterprises using them could be found. Neither did industry information provide useful information. At most it can be said that these materials are transported both by road and by rail (IBM 2018a).

IBM (IBM 2018a; IBM 2019d) highlights that a number of mines are vertically integrated within the operations of manufacturing plants, cement and steel predominantly. For non-vertically integrated operations it is unclear whether their production is undertaken as part of offtake agreements or prior to the identification of a buyer.

CRUSHED ROCK

Transport takes place between the extraction site and the rock crushing unit, and, later between the crusher and the construction site. Whether the trucks ferrying materials from the extraction sites to the crusher belong to the crusher or to the mining operator or are contracted to third parties is unclear at this stage.

There is no physical marketplace for aggregates, individual rock crushers get in touch directly with building contractors. The crusher is paid after reception of the aggregates.⁴¹ Transport to the construction site is paid for by the crusher and aggregates are transported by a contracted third party.⁴² These transport service providers are small to mid-size players with up to 20–30 trucks.⁴³

³⁹ Interview with Prem Mahadevan.

⁴⁰ See for example: https://www.youtube.com/watch?v=WgDIYj6kqio&feature=emb_title or <https://sandrp.in/2020/05/28/yamuna-riverbed-mining-miners-govts-throw-rule-book-in-river/>, as accessed on 03.06.2020.

⁴¹ Interview with Pradip Chopra.

⁴² Interview with Pradip Chopra.

⁴³ Interview with Vikash Nayak.

CEMENT

Depending on the size of the different supply chain actors transport can take places from cement plants to stockists to retailers to construction companies or skip a number of these steps. Typical supply chain arrangements from the plant to the final users and their corresponding value and market share are not known at this stage.

3.2.6. END USAGE IN CONSTRUCTION

It was estimated in 2011 that there were around 31,000 companies in the construction industry in India, 29,600 of which are small scale enterprises, around 1050 medium scale⁴⁴, and around 350 large scale (Negi and Ahuja 2017). Given the construction boom required to host the rural-urban migration in India as well as the development of its urban middle-class efforts, any decrease of the carbon footprint and related resource extraction of India's construction sector would go a significant way towards achieving the country's 2° target. As India's residential and commercial buildings account for 24% and 9% of the country's total electricity consumption these efforts not only target the resource and carbon efficiency of the materials used and the construction methods employed but also the design of buildings going forward (TERI 2019).

To that effect the Government of India has promulgated a number of policies, such as the aforementioned fly ash notification (see section 3.2.4.), which has been complemented by State level notifications in certain states (Odisha, Madhya Pradesh and Bihar). In line with these efforts BIS has issued production and performance standards for fly ash bricks and their inclusion is taken into account during public tenders (GIZ 2016). A national system to rate the "greenness" of buildings was also developed. The Green Rating for Integrated Habitat Assessment (GRIHA) for buildings with a built-up area ranging from 2,500 to 150,000 m² rates said building across a set of 34 criteria looking at the use of sustainable building materials in construction, in addition to operating energy efficiency and

design and siting parameters (GIZ 2016). For example, GRIHA Criterion 19 focuses on the utilisation of BIS recommended waste materials (such as fly ash, blast furnace slag, etc.) in building structure (GRIHA 2015):

- ▶ Minimum 15% replacement of Ordinary Portland Cement with fly ash by weight of cement used in structural concrete;
- ▶ Minimum 40% composition of building blocks/bricks by fly ash by volume, for 100% load bearing and non-load bearing walls;
- ▶ Minimum 15% replacement of Ordinary Portland Cement with fly ash in plaster/masonry mortar.

In addition, guidelines for the use of C&D waste recycling and reuse are also being developed. MoHUA has drafted a *Strategy for Promoting Processing of Construction and Demolition (C&D) Waste and Utilisation of Recycled Products* (MoHUA 2018). Concrete steps have also been taken to facilitate the adoption of these policies, for example the Building Materials & Technology Promotion Council of MoHUA has developed a Ready Reckoner for the Utilization of Recycled Produce of Construction and Demolition Waste (BMTPC 2018).⁴⁵ And while this reckoner clearly defines the implementation process along with the duties and responsibilities of various stakeholders involved, including the local authority its usage remains limited (TERI 2019).

More economical incentives are also being deployed to incentivise adoption of more sustainable practices. Builders that certify their projects as green receive a 5% additional FSI allowance,⁴⁶ or in other words can build 5% more floorspace within the same property. No measures on the impact of the incentive scheme could be located in secondary sources at the time of writing. However, with the exception of GRIHA, which implements ex-post checks, merely registering the project as green is sufficient to qualify for the incentive (TERI 2019). This could lead to extensive greenwashing as monitoring and enforcement remains limited on the ground,⁴⁷ especially as policy implementation, coordination, oversight and monitoring

⁴⁴ Small and medium scale enterprises are understood in India as enterprises in the manufacturing sector where the investment in plant and machinery or equipment is between Rupee 2.5 to 50 millions (or about 30,000 to 560,000 Euro) for small scale enterprise and from Rupee 50 to 100 millions (or about 560,000 to 1,170,000 Euro) for medium scale enterprises. Refer to the Micro, Small & Medium Enterprises Development Act, 2006 for further details.

⁴⁵ Accessible via http://164.100.228.143:8080/sbm/content/writereaddata/C&D%20Waste_Ready_Reckoner_BMTPC_SBM.pdf, as accessed on 07.06.2020.

⁴⁶ Interview with Pradip Chopra.

⁴⁷ Interview with Pradip Chopra.

would require inter-ministry cooperation (TERI 2019). For example, despite the multiple efforts deployed to strengthen the uptake of fly ash bricks these still command a higher taxation rate (12%) than clay bricks (5%) (TERI 2019).

These price differences are crucial as the sector is incredibly price-sensitive and building green still costs more⁴⁸ and final consumers are not sensitive to environmental performance for its own sake.⁴⁹ To the extent that certain solutions touted as being environmentally friendly, such as the use of fly ash bricks or m-sand, enjoy little confidence in the general public who does not want constructors to *experiment with their house*.⁵⁰

At this stage, relevant and specific information on market demand has not been identified, outside of broad statements. Most of the information gathered by the desk review being either biased towards big construction companies operating in the centre of the Metropolises and not taking into account the development of peri-urban sprawl, or, not Delhi NCT specific.

While the construction sector is India’s second source of employment after agriculture and employs more than 40 million migrants (Chinnadurai and Jayamani, 2019) working conditions on site present a number of gaps from a labour and human rights perspective as

reported by research conducted in the organised medium- and large-scale segments of the construction sector in Delhi NCR (CDPR 2014):

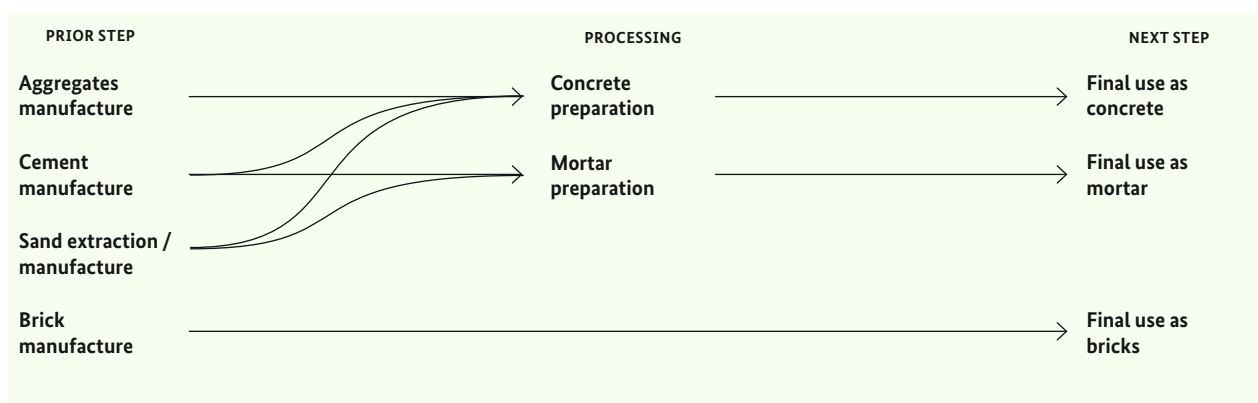
Forced labour is endemic in the construction sector as the majority (84%) of workers are contracted through labour brokers. Workers regularly have to request advances as their wages are only paid upon completion of their work and 94% of migrant workers do not have a formal contract. The average daily wage for unskilled construction workers is about two-thirds of the official minimum wage and wage payments are often irregular.

Occupational health and safety presents major gaps, and working conditions present risks both in the short and in the long run. PPE is virtually never issued to workers, including tethering (BBC 2019) or dust protection equipment. As a result, more than half of construction workers complained about work-related health problems (such as respiratory issues and back pain). As most workers (92%) have no access to injury compensation or health benefits (94%) they rely on unregistered private medical practitioners for their healthcare. Men and women labourers at construction sites who handle cement or are exposed to it are at high risk of contracting skin infections owing to its chemical composition (Outlook 2019).

Living conditions. The vast majority of construction workers (more than 70%) live in fenced-off and guarded areas, either on or off site, and most often in temporary sheds. It is not uncommon for whole families to migrate together and they must then stay together in these camps. Provision of sanitation and water is lacking and electricity supply is intermittent.

⁴⁸ Interview with Sanjay Seth, Megha Behal, and Ankita Bokhad.
⁴⁹ Interview with Pradip Chopra.
⁵⁰ Interviews with Sanjay Seth, Megha Behal, and Ankita Bokhad, and, Pradip Chopra.

Figure 12 – On-site processing and end usage of aggregates, cement, sand and bricks



Corruption and bribery. As noted in section 3.2.2. on sand extraction, GITOC (2019) describes the following situation: “builders sit atop large construction companies that undertake infrastructure projects offering multiple opportunities for corruption. In return for donations to political parties, the builders exploit their proximity to policymakers and thus deter law-enforcement personnel from pursuing them.”

Right to free association and collective bargaining. Unions are not present on construction sites nor any other collective organisation, despite being present in Delhi NCR. Workers are afraid to lose their job would they get involved with a union and the tight security at work and the campsites discourages contact.

Gender and discrimination. In addition to the structural disadvantages faced by migrant labourers hired through labour brokers, female workers face additional hurdles. While in 2014 nearly a quarter of the workers were female, due among other to the migration of

whole families, the industry is becoming more ‘masculinised’ as contractors prefer young males, able to work harder according to them. They are thus restricted to low-skilled work, and only make three quarters of the pay of males. In 2014 the average monthly wages of female unskilled construction workers was equivalent to about 78 USD a month.

Misdeclaration of origin of minerals. There are no requirements for construction projects to track the origin of their raw material supply nor is it necessary to highlight the plausible origin of materials when applying for a construction permit.

3.3. Indonesia

3.3.1. MATERIAL SELECTION

The following mineral commodities have been selected for further analysis. Their extraction, processing, manufacture, trade and final usage will be detailed in the following sections. Note that in the value chains presented below elements not highlighted in green are not discussed specifically in this report but nevertheless shown to accurately represent the respective supply chains. The visual representations of the value chains must be regarded as preliminary and simplified and will be refined as further information is gathered on the specific actors involved and processes taking place in the selected metropolitan area in the second research phase.

SAND AND GRAVEL

Indonesia has important deposits of sand and gravel, and it is a material widely used in the construction sector. Sand extraction is particularly important

to study because of its severe environmental impacts and its widespread informality.

CRUSHED ROCK

Different types of crushed rock are produced across Indonesia and used in construction. It is a sector that involves many small and informal businesses, pointing towards its importance for local livelihoods.

DIMENSION STONE

Different types of dimension stones are produced across Indonesia for use in the construction sector. Marble and sandstone have confirmed extraction in East Java and the study area. Information is not readily available, which makes the need for further study even more pressing. The lack of information about dimension stone value chains have meant that no preliminary visual representation of the value chain could be produced.

Figure 13 – Sand and gravel value chain Indonesia

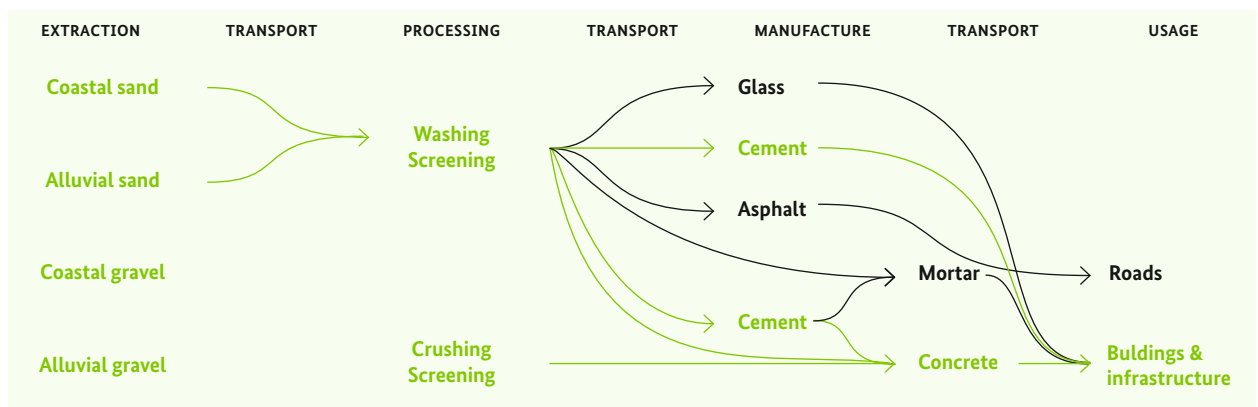
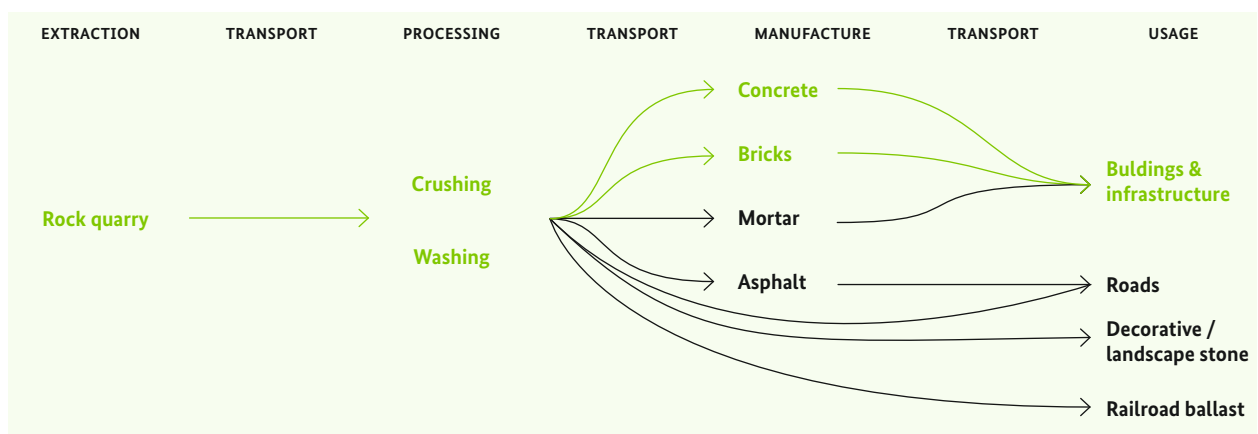


Figure 14 – Crushed rock value chain Indonesia



LIMESTONE

Limestone is an important raw material extracted across Indonesia because of the increasing cement production in the country. Also here there is an important informal sector composed of small businesses. In East Java, due to its extraction in a mountain range, limestone extraction is likely to have severe environmental impacts.

CLAY

Clay is extracted across the country, and used in cement production but also for ceramics, bricks and tiles. Bricks produced in East Java seem to consist primarily of clay, which is why this material has been selected as an important one for in-depth study. Preliminary research points towards issues of migrant labour and discriminatory practices.

3.3.2. EXTRACTION AND RECYCLING

The mining sector in Indonesia contributed 4.71% of the country’s GDP in 2017 and 14% of exports. The sector contributes in important ways to tax state revenue and to royalties and other nontax state revenue. The mining industry also contributes importantly to employment creation, with around 1.4 million workers being employed in the sector in 2017 (Indonesian Mining Institute 2018). While the GDP growth rate in the Indonesian mining and quarrying sector has

been relatively stable – 2.2% between 2005 and 2009, and 2.4% between 2010 and 2014 – the employment growth rate has declined significantly, from 6.3% between 2005 and 2009 to 2.7% between 2010 and 2014 (Aswicahyono, Hill, and Narjoko 2012).

Two branches of the Ministry of Energy and Mineral Resources (MEMR) are responsible for governing the mining sector at the national level, namely the Directorate General of Mineral and Coal (DGMC) – responsible for policy formulation and implementation and granting national level licenses, and the Geological Agency – responsible for determining license areas for auction and providing geological research and services. At the provincial level, also two government bodies are responsible for managing the mining sector, namely the governor who is responsible for granting mining licenses in the province, as well as related permits, and the Dinas ESDM, responsible for monitoring and supervision of mining in the province (Indonesian Mining Institute 2018). Other agencies involved in the governance of the mining sector are: At national level: Ministry of Environment, Forest and Climate Change, Ministry of Land and Spatial Planning, Ministry of Finance; and at provincial level: Environmental Agency, Forestry Agency, and Spatial Planning Office.

Figure 15 – Limestone value chain Indonesia

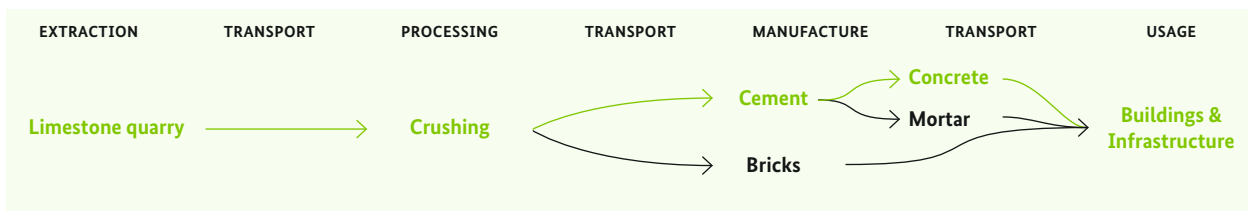
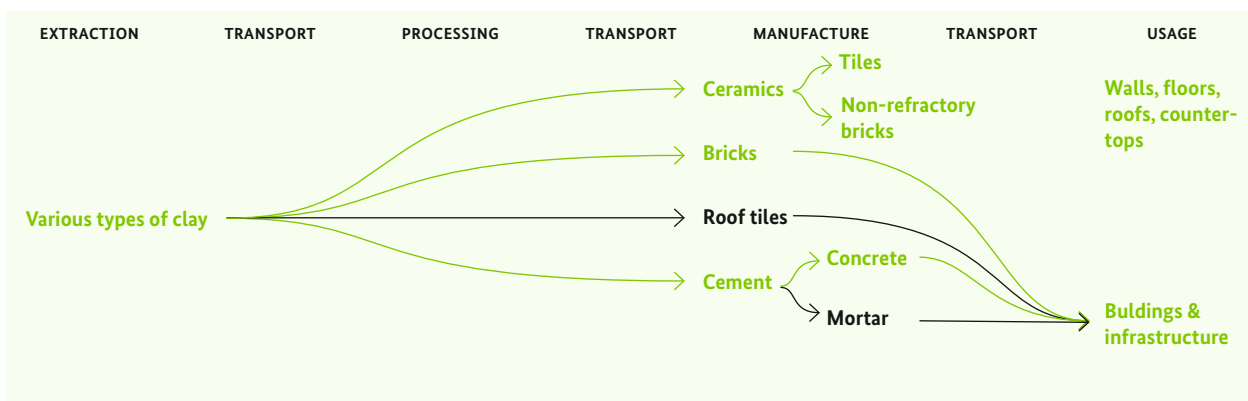


Figure 16 – Clay value chain Indonesia



Indonesia's Government Regulation number 23 (2010) divides mining commodities into five classes, namely radioactive minerals, metal minerals, non-metal minerals, rocks, and coal. The raw materials that are subject of this study fall into the non-metal minerals and rock classes.⁵¹

There are three types of mining licenses in Indonesia: The mining business license (Ijin Usaha Pertambangan (IUP)) for large-scale mining; the special mining business license (Ijin Usaha Pertambangan Khusus (IUPK)) for state reserve areas for projects of national strategic interest; and the people's mining license (Ijin Pertambangan Rakyat (IPR)). Licenses for exploration and production are different (Devi and Prayogo 2013).

People's mining in Indonesia is artisanal and small-scale mining, meaning non-mechanised and labour intensive mining. Local participation in the governance of ASM has been strengthened, which is why the Regent/Mayor is now allowed to issue artisanal mining licenses (Law 4/2009), to decide on areas for ASM (Law 22/2010), and to monitor and regulate ASM (Law 55/2010). ASM often occurs in the informal economy, not being formally authorised by the government. 90% of all ASM miners are considered illegal by the government (Devi and Prayogo 2013). As in many countries, the sector suffers from environmental, social and health risks. ASM is a widely unregulated industry, with the sub-national governments not being very involved in its management (Devi and Prayogo 2013). The government also does not consistently offer training to ASM in an effort to improve their activities, training only being available in certain provinces (Indonesian Mining Institute 2018).

A term related to people's mining and utilised in this report is the one of household businesses, which are typically small-scale businesses consisting of family members as managers, owners and workers. They usually produce small volumes and use simple equipment. Household businesses are typically identified as being informal, or semi-formal, meaning they do not comply fully with the permit requirements of the government.

Law Number 4 of 2009 concerning Mineral and Coal Mining (Minerba Law) is the main law regulating the mining sector in Indonesia. The House of Represent-

tatives ratified the revision of the latest Minerba Law on May 12th 2020. Under the new Minerba law, the People's Mining Area (WPR) can be maximum 100 hectares in size, up from 25 hectares in the previous version of the law (Ramli 2020). Under the new mining law the control of metal minerals is given to the central government. However, the management of non-metal and rock minerals as well as artisanal mining can be delegated to the regional government (Ramli 2020). The new Minerba law established the new Rock Mining Permit (SIPB). The SIPB is granted by the governor and can be requested by a regionally or village-owned business entity, a private business entity in the context of domestic investment, or a cooperative. The mining area can be maximum 50 hectares large. Small-scale rock permits will be granted by local governments.

According to the Minerba law, mining without a permit is punishable by a maximum prison sentence of 5 years, and a maximum fine of Rp 100 billion. The same punishment is applicable for license holders who intentionally submit fraudulent reports or false information, for those holding an exploration license only but also conducting production operations, and for those processing/refining, transporting, or trading minerals originating from unlicensed mine sites.⁵²

The revised mining law has been criticised for giving greater rights to mining companies, including longer contracts and larger concessions. Environmental groups have expressed concerns about the environmental repercussions that the new regulations will have (Jong 2020).

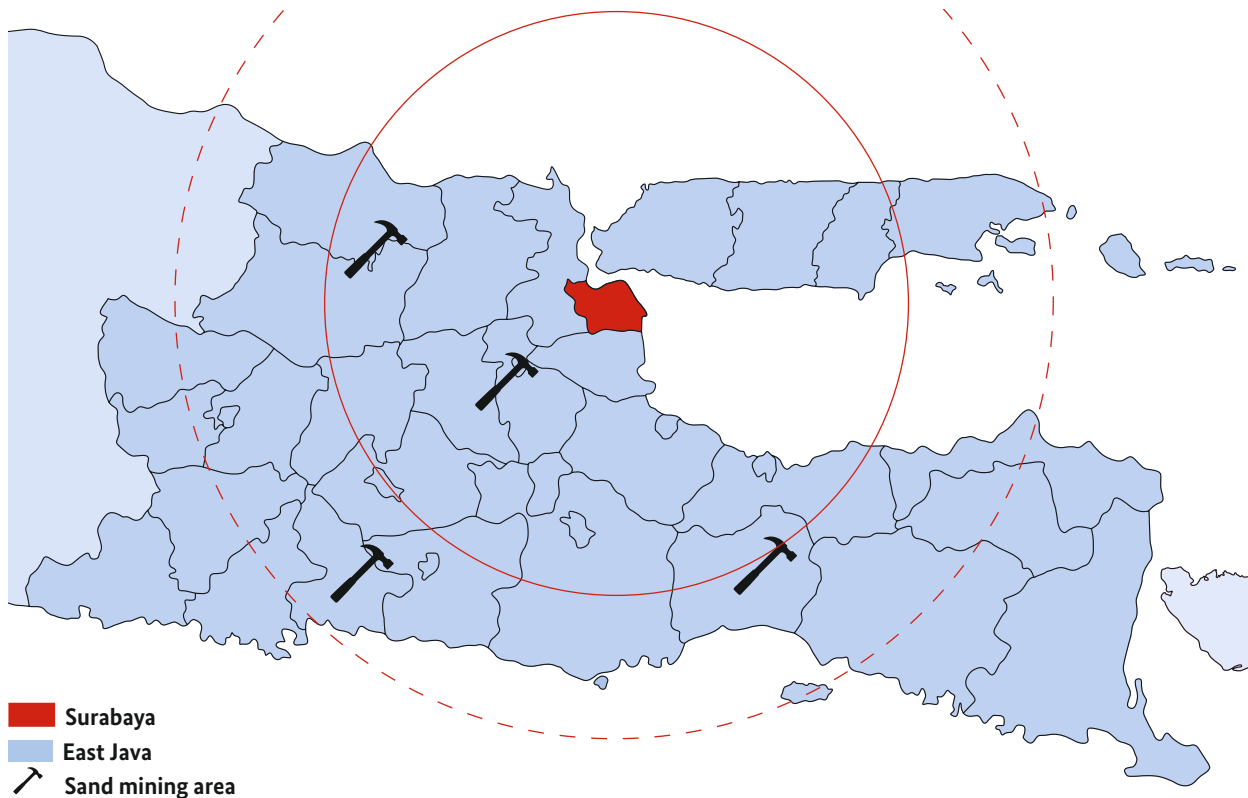
The governance and regulation of the mining sector is negatively impacted by two factors: The national and sub-national governments do not coordinate enough in implementing policies. Further, sub-national governments lack human resources and institutional capacity to monitor and regulate mining activities adequately (Devi and Prayogo 2013).

On the positive side, the Indonesian government has made efforts to promote downstream processing and local inputs in the mining sector, and even introduced some protectionist policies (Devi and Prayogo 2013). The government has shown support for value addition and domestic mineral use, and greater participation of Indonesian businesses and communities

⁵¹ Government Regulation 23 (2010).

⁵² Minerba Law, revised version (2020).

Map 7 – Sand mining locations around Surabaya



in mining (World Bank 2013). Under Indonesian law, mining companies must use nationally produced goods, local services and technology as well as a national workforce, therefore creating strong local content requirements (Devi and Prayogo 2013).

SAND AND GRAVEL

Sand is found across all regions in Indonesia. In 2018, a total of 251.2 million m³ of sand were extracted in the country, of which 242.7 million m³ by household businesses and 8.5 million m³ by legal businesses. Production value of legal businesses was Rp. 724.65 billion in 2018, and Rp. 17,397.86 billion for household businesses (Nuryati 2019). The price of sand and gravel in Central Java, where they are readily available, is between Rp. 70,000 and 90,000 per m³ (4.41 – 5.67 EUR) (Suraji 2007). Household businesses dominate the sand market, with 61,528 businesses employing 200,920 people versus 159 legal businesses employing 4,067 people. There are large wage discrepancies between the legal and the household business sectors which contrast the much higher production volume and value of the household business sector (Nuryati 2019), which points towards a poorly regulated sector with low wages.

Sand is hence extracted mainly informally and on a small scale. Small businesses with limited capital struggle to achieve legal status. The interviewees from the Trade and Industry Agency in East Java pointed towards a poorly regulated sector, with the involved sand and gravel businesses being less willing to share production data with the Agency. They usually only share data with the Integrated Licensing Management Office when they need to apply for a permit extension, and even then the data is often not accurate (Interview, Trade and Industry Agency, East Java, 01 June 2020).

In the surroundings of Surabaya and in wider East Java, sand mining is taking place amongst others in Lumajang regency, 150 km southeast of Surabaya, along the Bengawan Solo river near Simo village (Tuban), in Tulungagung, and in Trowulan, less than an hour away from the city (Jones and Perkasa 2019). Map 7 shows those locations and indicates that sand mining is taking place all across the interest area.

In terms of Indonesia-specific social and environmental impacts, most of the secondary literature points towards environmental damages and disappearance of islands, smuggling of material due to an export ban,

and violent clashed and conflict with communities and environmental activists.

Impact on landscape. Sand extraction in Indonesia has significant environmental impacts. This includes erosion of river banks, water turbidity, abrasion and damages to the coastal ecosystem. At least 24 small islands have disappeared across the country since 2005 because of excessive sand extraction (Pearce 2019). In 2007, the government banned the export of sand and gravel to prevent the environmental devastation.

Corruption and bribery and smuggling. The export ban from 2007 has led to increased sand smuggling out of the country. The smuggling is facilitated by corrupt local officials.

Violence and conflict are regular occurrences in the sand mining sector. Informal businesses are vulnerable to police raids or disagreement with communities. In Lumajang regency there have been clashes with villagers due to the illegal activity (Jones and Perkasa 2019). Also environmental activists and sand miners regularly end up in confrontations. Complaints by environmentalists range from landslides to muddy water to damaged roads. Violent actions are undertaken by miners against environmental activists in an attempt to silence them (Rakhman and Nugraha 2019).

CRUSHED ROCK

Rocks for construction are extracted across Indonesia, and many varieties of it. The rock quarrying sector in 2018 counted 293 legal businesses with 10,778 workers and 31,388 household businesses with 103,588 workers. The legal businesses produced 16,423,974 m³ that year, or Rp. 4,942,447,000,000 in value, and household businesses 29,186,313 m³, or Rp. 9,922,805,000,000 (Nuryati 2019). These figures show that the majority of rocks are extracted in the informal sector. It needs to be clarified which types of rocks fall under these statistics.

A study from East Kalimantan, around the city of Samarinda, provides insights into the rock quarrying sector in Indonesia. Most stonecutters are of Madurese descent (from the island of Madura just off the coast from Surabaya) and live in simple sheds or house on the outskirts of the city, many city inhabitants not even being aware of the amount of Madurese living and working in the area. Men are usually responsible for cutting, women for crushing, using simple tools like hammers, chisels, levers and shovels.

Fire is used to facilitate cracking of the rock. Sometimes middlemen use excavators to remove sand and rocks and create roads for trucks. The stonecutters sell the rocks for road building and construction work. Working conditions are difficult, and earnings are low and dependent on location, the construction sector and the weather. The best earnings are up to 10 EUR a day, the lowest less than 1.50 EUR per day. Some of the quarries are owned by Chinese nationals (Nooteboom 2008).

Forced labour is a risk in the Indonesia rock quarrying sector. In the vicinity of the city Samarinda, East Kalimantan, there have been reports of situations of debt-bondage of rock miners with middlemen. However, this only really happens for workers of Madurese descent, not for other ethnic groups (Nooteboom 2008), pointing towards discriminatory practices.

Corruption. There are reports of semi-legal rock quarry workers in Indonesia having arrangements with the police, who protect their businesses and facilitate illegal activities while taking a premium. For unlicensed rock businesses, this is typically 5 – 20% of earnings (Aspinall and van Klinken 2010).

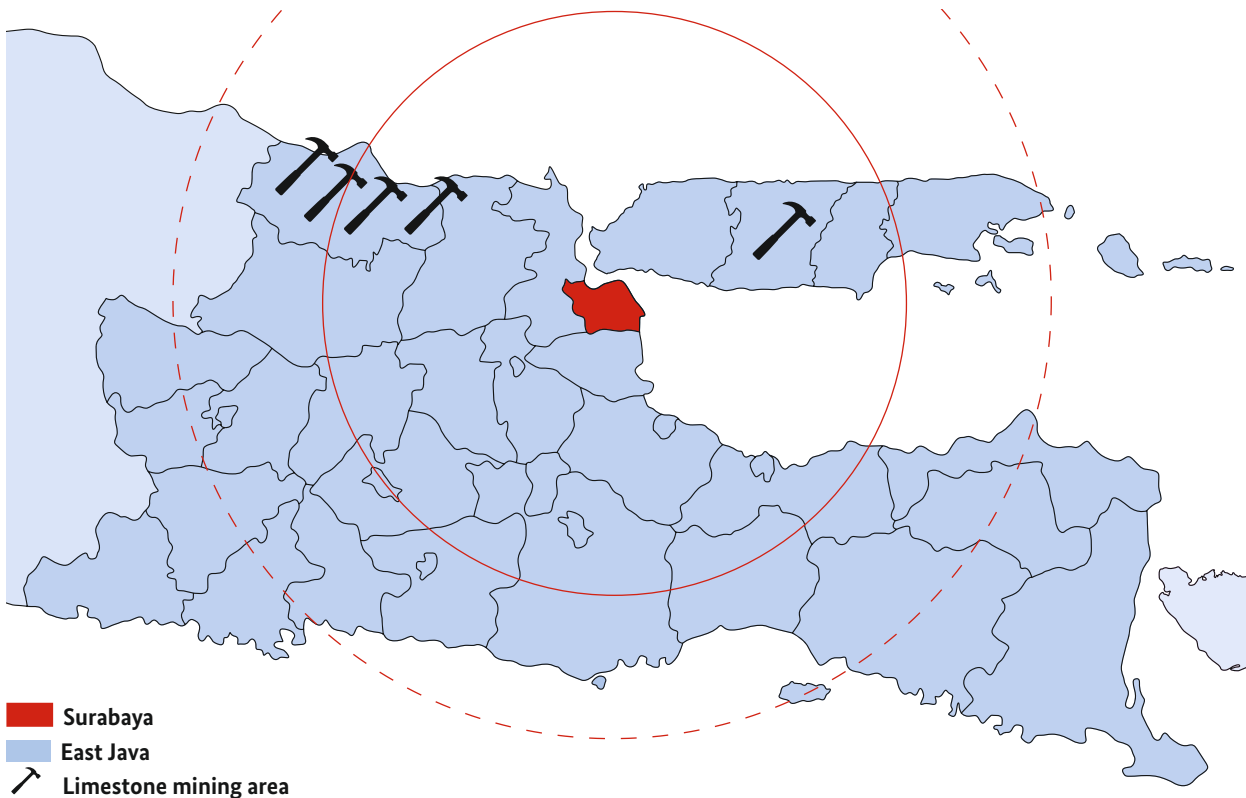
Worst forms of child labour. In 2001, children have been found working in Indonesian rock quarries, mainly boys between 11 and 15 years old. They were involved in finding big rocks in water and breaking rocks into smaller pieces. The health and safety conditions and equipment were poor, children having been exposed to heavy lifting and injuries as well as cramps and spasms from being in the water (International Labour Organization 2001). More current information will be collected during the field research phase.

Environmental impacts are common in the extraction of rocks in Indonesia. They include noise and dust pollution from the use of explosives, as well as deforestation.

LIMESTONE

Limestone exists and is extracted across the country. Limestone production in Indonesia in 2015 amounted to 649,113,288 tonnes, dolomite production to 2,714,221 tonnes (Ministry of Energy and Mineral Resources 2015). In 2018, a total of 7.26 million m³ of limestone were produced in Indonesia, around half of it by legal businesses and half by household businesses (Nuryati 2019). The demand for limestone is rising due to the increased cement production in the country (ITE Build & Interiors 2016). Legal businesses pro-

Map 8 – Limestone mining locations around Surabaya



duce much more volume per company than household businesses, with there being 58 legal business units and 2,363 household business units extracting limestone in the country (Nuryati 2019). The legal sector employed 3,766 people in 2018, the household sector 5,824 people. That means that one household business unit employs between 2–3 people (Nuryati 2019). The process to obtain a limestone extraction permit is complex and expensive, which is why there is an important informal sector.

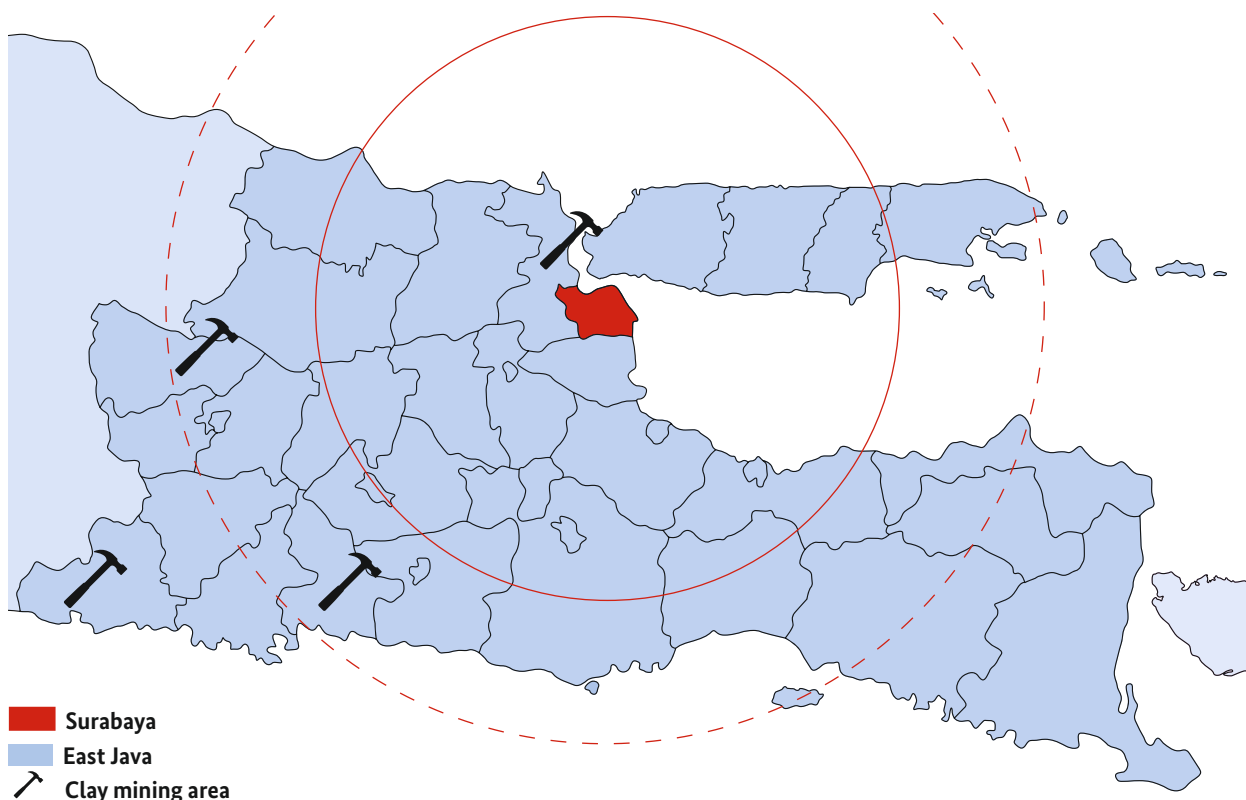
Limestone extraction in the surroundings of Surabaya is taking place in the city of Gresik, around 20 km away from Surabaya city centre, and on Madura island just off the coast from Surabaya. The island reserves are around 152,219,027,133 tonnes. The deposits currently have low economic value (Munawaroh et.al. 2018), which might change with increasing demand for cement production. Limestone and gypsum are also extracted from the Kendeng Mountains, reaching from North to Central and East Java (Tuban) (Keller and Klute 2019). Important limestone deposits also exist in Tuban Regency, more specifically the Districts of Kerek, Merakurak, Tambakboyo, Palang, Semanding and Montong (Sukojo and Majid 2019). These locations are indicated in Map 8. The informa-

tion on extraction location is however not complete and the map therefore only gives a preliminary indication about some confirmed areas of extraction.

Impact on landscape and competing land uses. The extraction of limestone can cause damage to natural landscapes, changing the morphology and topography and thereby soil and rock characteristics (Djakamihardja and Mulyadi 2013). Large-scale limestone mining involves blasting and therefore noise, and can cause air pollution and water pollution. Extraction of limestone from the Kendeng Mountains has endangered the mountains' karsts. The mining activity poses problems for water supply, the bird population and smallholder agriculture. Twenty percent of Java's karsts have already been destroyed. The cement lobby even manages to receive mining licenses for karsts in protected areas, amongst others in the Kendeng Mountains. According to national laws, karst regions are protected geological zones (Keller and Klute 2019).

Conflict. Due to competing land uses and environmental damage caused in the Kendeng Mountains, there are conflicts with community members about

Map 9 – Clay mining locations around Surabaya



the establishment of limestone extraction sites and factories (Keller and Klute 2019).

Violence. Limestone actors working informally are vulnerable to extortion by police officers, to police raids, confiscation of mining equipment and prison sentences.

DIMENSION STONES

Granite is present in several provinces of Indonesia, but not in East Java. Its extraction is entirely in the formal sector, with 11,278,346 m³ extracted in 2018, by 2,054 workers. The workers earned Rp. 144,454,000,000 in 2018, the production value was Rp. 2,693,673,000,000 (Nuryati 2019).

Not much information is available on sandstone mining in Indonesia, apart from it being used as a construction material and for road construction. Small-scale sandstone extraction – of the type used for grindstones – is taking place in Pacitan, East Java.

Marble production is not very large in Indonesia, and deposits are only found in a number of places. Production in 2018 was 132,254 m³ for 20 legal businesses and 3,666 m³ for 84 household businesses (Nuryati 2019).

The production value in 2018 was Rp. 324,254,000,000 for legal businesses and Rp. 1,796,000,000 for household businesses (Nuryati 2019). In East Java, marble is found in Panggul, Campurdarat and Pacitan.

CLAY

Clay is found in almost all provinces of Indonesia. In 2015, Indonesia produced 2,542,013 tonnes of kaolin, 1,805,802 tonnes of bentonite, and 240,893,509 tonnes of clay (Ministry of Energy and Mineral Resources 2015). In 2018, 41 legal businesses (1,187 workers) produced 3.42 million m³ of clay, and 686 household businesses (2,232 workers) produced 3.94 million m³. Production value was Rp. 301,032 million for legal businesses and Rp. 174,977 million for household businesses (Nuryati 2019). It is unclear which types of clay are included in this statistic.

Clay in the Surabaya area can be found and is extracted amongst others in Gresik, Tulangagung, Pacitan and Ngawi. Map 9 shows these locations and suggests that clay is found across East Java.

Impact on landscape and competing land uses. Clay extraction can have a negative impact on the landscape and the fertility of the soil, as it starts with the

opening of the soil layer. The activity can therefore harm the prospects of agriculture in the area of extraction.

Corruption and bribery. There are reports of semi-legal clay extraction workers (for brick production) in Indonesia having arrangements with the police, who protect their businesses and facilitate illegal activities while taking a premium. For unlicensed rock businesses, this is typically 5–20% of earnings (Aspinall and van Klinken 2010).

3.3.3. PROCESSING

The Indonesian government has made efforts to promote domestic value addition through the Ministerial Regulation MEMR 7/2010 which banned the export of raw materials from 2014, with the aim of developing a larger value-adding downstream industry. Companies need to develop refining and processing industries in the country (Devi and Prayogo 2013). According to Ministerial Regulation 5/2017, non-metal and rock minerals need to undergo basic processing before they can be exported. Certain non-metal and rock minerals cannot be exported at all, following the Minister of Trade Regulations 45/2019. Among the minerals examined in this study that are prohibited from export are limestone sand, sand, quartz sand and clays. Minister of Trade Regulation 69/2019 defines minimum processing requirements for materials intended for export. Minerals subject to this Regulation include milled limestone, slate, marble, granite, gravel and perlite. Representatives from the Ministry of Trade said that the purpose of this legislation is to avoid selling state assets and to use natural resources for the welfare of the country and the benefit of Indonesian citizens. While acknowledging that business actors would have felt the impact of these regulations, they said that in the future companies will benefit from selling products of higher economic value after processing (Interview with Ministry of Trade, 13 May 2020).

Basic processing like crushing, washing and screening of material often takes place on the site of extraction, and sometimes in specific processing areas or operations. No specific information could be found through desk-based research on these processing activities. To understand this step in the value chain better, field work is required to assess where the processing takes place, what activities are undertaken and by whom, whether there is transport between the different stag-

es, whether the material changes owner, and the social and environmental conditions of the processing.

3.3.4. MANUFACTURING

Most information has been found on cement and bricks manufacturing, which this chapter focuses on. During fieldwork other important manufacturing processes might be identified, and subsequently added to the scope of the project.

CERAMICS

Clays are amongst others used for the production of ceramic products. Ceramics are common as tiles used for floors, walls, roofs, countertops and fire places, as well as non-refractory bricks (“Ceramics and Glass in Construction” n.d.). The clay tiles and earthenware industries count 526 and 204 businesses respectively in East Java (Interview, Trade and Industry Agency, East Java, 02 June 2020).

According to an interviewee from an Indonesian ceramics company, local entrepreneurs are rarely involved in the medium- and large-scale ceramics business, as they cannot compete in terms of connections and capital. The ceramics business in Indonesia is further dominated by Chinese entrepreneurs. The interviewee advocates for domestic value addition in order to increase the benefits created in Indonesia (Interview Ceramics Industry Representative, 13 May 2020).

BRICKS

The majority of houses in Indonesia are now made of masonry, as opposed to wood, typically red bricks and made by hand (Roachanakanan and Nichols 2009).

The Trade and Industry Agency in East Java reported that the construction material that counts the highest number of businesses in production is bricks, with around 4,158 business units being involved – both as producers and as distributors. All of them are small- and medium-sized businesses. Clay is the most common basic ingredient of the bricks produced in East Java (Interview, Trade and Industry Agency, East Java, 02 June 2020). According to an interlocutor from a ceramics company, lightweight bricks are becoming increasingly popular in Indonesia. They are made from clay, quartz sand, lime and gypsum amongst others (Interview Ceramics Industry Representative, 13 May 2020).

The traditional brick making process in Indonesia involves the stages mixing of raw materials includ-

ing clay, sand and ashes, moulding, drying and firing. These processes have been handed down through generations (Atmodiwirjo et al. 2018). The traditional firing fuel used in Indonesia is rice husks. Firing is usually done in an open kiln, and bricks moulded by hands. Per plant, there are usually 5–7 workers. The typical plant production capacity per day is 700 bricks, or 140 bricks per worker, and a unit of bricks costs 5 US cents. A typical masonry house needs 6,000 bricks. (Roachanakanan and Nichols 2009).

A study on brickmaking by Madurese immigrants in East Kalimantan shines light on conditions that might also be found in East Java and around Surabaya. Brickyards usually are made of a simple barn where stones are parched and baked, and are installed where the clay is located, which means they change location regularly. Usually the workers rent or lease the land they work on, only 15% of them own the land. Brick makers use simple tools like shovels and moulds. The research found that 40% of brickyards were family-owned, while 60% were made up of around six employed workers (Nootboom 2014).

Forced labour. In East Kalimantan, many Madurese workers have high debts towards the brickyard owner because of provision of housing, cash advances or loans, and therefore find themselves in bonded labour relations. These kinds of labour relations were found on around half of the brickyards studied by Nootboom (Nootboom 2014). Given the close proximity of Madura island to Surabaya, it is likely that Madurese labourers are also engaged in brick production in the study area.

Worst forms of child labour. Data from 2001 pointed towards child labour in the roof-tiles and brick industry in Indonesia. Updated information needs to be collected during field research.

Earthquake safety. Since the houses in Indonesia are built predominantly from clay bricks rather than wood as was traditionally the case, there are increasing issues of safety during earthquakes. This is the case in particular if the bricks are soft and have been poorly fired (Roachanakanan and Nichols 2009). A study of bricks in East Java found that the compressive strength of bricks was between 0.55 and 0.9 MPa, and the modulus of elasticity of low-quality bricks was between 279 and 571 MPa. This is lower than in most countries that the researchers compared it to, and therefore the quality is worse. Improving the quality of bricks in Indonesia in particular for earthquake-preparedness is a

challenge because the industry is dominated by family businesses (Ridwan, Kurniawan, and Agus 2018).

CO₂ emissions. The environmental impacts of brick manufacturing mainly stem from air emissions and high energy consumption during the firing of clay bricks. More modern kiln systems have proven to be more environmentally friendly but are often not accessible for traditional brick making businesses as they are more adapted to industrial-scale mechanised processes. Other efforts to improve the environmental footprint of brick productions include reducing the temperature and therefore energy in the firing process through the use of specific clays, and using organic and inorganic waste materials as an additive to the bricks. However, the latter doesn't come without problems in the traditional brick making industry: the cost of adding waste materials often is higher than the economic benefit, and during the firing process, the waste materials might release contaminants (Atmodiwirjo et al. 2018).

CEMENT

The Indonesian government has identified cement as a strategic material (Abduh and Pribadi 2014). Production capacity in the country has risen from 47 million tonnes per year in 2004 and 2005 to 61 million tonnes per year in 2012 (Panjaitan et al. 2018). In 2015, the Indonesian cement producers produced a total of 75 million tonnes (CGI 2015). Indonesia is thereby the worldwide fifth largest cement producing country, after China, India, the U.S. and Iran (Keller and Klute 2019).

There are 42 cement plants in Indonesia, 6 of them being located in East Java, namely in Tuban (2), Gresik (2), Jember and Banyuwangi (CemNet 2020). Semen Indonesia Group is the country's largest cement producer, having a market share of 47% and capacity of 50.7 Mt per year (ZKG Cement Lime Gypsum 2019).

Domestic cement consumption is also up from 32 million tonnes per year in 2004/5 to 51.8 million tonnes in 2012 (Panjaitan et al. 2018) and 69.51 million tonnes in 2019 (Bisnis 2019). Most sales and consumption of cement in the country in the first half of 2018 took place in Java (56% of the total), followed by Sumatra with 22% and Sulawesi with 8% (Indonesian Cement Association 2019). Out of the 6.5 million tonnes of cement sold in Indonesia in the month of August 2018, 874,535 tonnes came from East Java, which was the 4th highest producing province in the country. Exports of cement in August 2018 amounted to 541,143

tonnes (PT Semen Indonesia (Persero) Tbk. 2018). The largest consumer of cement is the residential sector (ZKG Cement Lime Gypsum 2019). Since 2008, cement sales in the country have increased every year, at rates of 1.1% in 2009, 4.2% in 2010, 20% in 2011, 14.6% in 2012, 5.6% in 2013, 3.3% in 2014 and 2.5% in 2015 (ITE Build & Interiors 2016). From 2018 to 2019, cement sales increased 9.5% to 7.088 Mt (CemNet 2019).

Since 2014, the national demand for cement has however decreased due to reduced economic growth and purchasing power. The resulting excess supply as well as rising energy prices and increased costs of labour and raw materials have negatively impacted the cement industry (Panjaitan et al. 2018). The Indonesian cement market is at overcapacity, having a utilisation rate of 70% in 2018 with production volumes reaching 75.1 million tonnes despite a capacity of 110 million tonnes. In 2016, there was a production oversupply of 27.7 million tonnes, due to capacity growing faster than consumption and a falling regional consumption for local housing in Jakarta, Banten and West Java (Indonesian Cement Association 2019; ZKG Cement Lime Gypsum 2019). Despite the utilisation of national cement production only having been 85% in 2012, the existing supply chain was unable to meet cement demands from the whole country in that year. Remote areas find cement prices to be very high because of restricted access (Abduh and Pribadi 2014). There is hence also an issue of distribution. The overcapacity of the market has led to a large producer (LafargeHolcim) to leave the country recently. This can open opportunities for local companies (Indonesian Cement Association 2019; ZKG Cement Lime Gypsum 2019).

The Indonesian cement industry has suffered economically since 2012 not only because of the oversupply and an unstable demand within the country, but also because of higher raw material prices. The domestic cement manufacturing industry is not competitive against cheap foreign import material, in particular from China. With the aim to protect domestic manufacturers, industry stakeholders have called for higher duties on imports (Oxford Business Group 2019).

There is a trend in Indonesia to replace the Ordinary Portland cement by Portland Pozzoland cement and Portland Composite Cement which have properties more suitable to certain environmental conditions (Abduh and Pribadi 2014).

CO₂ emissions and pollution. Cement producing companies harm the environment through the release of dust and toxic gases during manufacturing (Keller and Klute 2019). Cement is the manufacturing industry in Indonesia that emits the most greenhouse gases. The cement sector releases 40 million tonnes of CO₂ equivalents yearly, of a total of 600 million tonnes from the energy consumption and production sector (Panjaitan et al. 2018). The production of one tonne of cement releases 600 kg of CO₂ (Keller and Klute 2019). 90% of the energy needed for cement production goes into the making of clinker (composed of limestone and clay soils). An option for the reduction of emissions is the use of fly ash instead of clinker. Fly ash is basically waste from other industrial processes, containing silica, aluminium, and iron oxides. In the metropolitan area of Surabaya, cement plants are allowed to use industrial waste as raw materials – 1/3 of their raw materials were already copper slag, blast furnace slag or biomass waste in 2015 (Panjaitan et al. 2018; Amellina et al. 2016).

Also in concrete production, fly ash is commonly used. Concrete consists of cement, water, and fine and coarse aggregate (Darmawan et al. 2015). The Indonesian concrete manufacturing industry has been using fly ash from coal power plants for the past two decades. This process has two advantages, namely reducing material cost because of the reduced cement content, and reducing waste from power plants. However, high quality coal is becoming scarce in the country, and hence fly ash from lower quality coal is becoming more common. Competition between concrete manufacturers leads to many of them having to use less good fly ash which leads to lower concrete strength (Darmawan et al. 2015).

3.3.5. TRADING AND TRANSPORTING

Basically no information could be found on the trading and transporting aspects of the construction value chain in Indonesia. The only thing mentioned about the transport in the Indonesian construction sector is that transport to remote regions can be an issue, with access being difficult because of a lack of infrastructure (Abduh and Pribadi 2014). A further information found was that trucks of sand in Indonesia usually transport 2.5 – 3.5 m³ of material each, and cost about Rp. 300,000 – 350,000 (Suraji 2007). And finally, holders of people mining licenses are allowed to sell their products openly to the market (Indonesian Mining Institute 2018).

Field work will be used to find out about formality, actors, workforce, social and environmental issues, pricing, profits and taxes, as well as other aspects.

Related to trading and transport, an important barrier to the efficiency of local construction value chains has been identified in the literature: Construction value chains tend to be complex and composed of a large number of actors with competing interests and a lack of coordination between each other (De Groote and Lefever 2016). Indonesia for example has a highly fragmented construction supply chain, which leads to low productivity, disputes and cost and time issues (Abduh, Soemardi, and Wirahadikusumah 2012). The relationships between actors in the supply chain are ad-hoc, temporary and lack loyalty and stability (Abduh and Pribadi 2014), leading to fragmented project delivery (Supriadi and Sui Pheng 2018). This not only relates to trade and transport, but to business relationships more in general.

3.3.6. END USAGE IN CONSTRUCTION

The Indonesian construction sector had a GDP growth of 7.9% between 2005 and 2009, and 7.2% between 2010 and 2014. The employment growth rate in the sector between 2005 – 2009 was 4.7%, between 2010 – 2014 it was 5.4% on average (Aswicahyono, Hill, and Narjoko 2012).

There are different permits in the construction sector:

- ▶ An Individual Business Registration License (TDUP) provided by the regency or city government to individuals;
- ▶ a Business Entity Certificate (SBU) for Indonesian and foreign companies issued by the Construction Services Development Institution; and
- ▶ a Construction Services Business Licence (IUJK) provided by the regency/city government for local companies and the Capital Investment Coordinating Board for foreign companies.

Companies also must obtain several specific licenses before they start construction activities, namely a land utilisation permit, a building construction permit, an environmental permit and technical approvals. These are in general provided by the regional government (Rahmansyah 2020). Construction projects with a significant environmental impact must provide an Environmental Impact Assessment (Supriadi and Sui Pheng

2018). After the construction has been completed, a so-called Certificate of Worthiness has to be provided in some regions. In others, the regional government might ask for regular reporting and inspections (Rahmansyah 2020).

In order to support the construction industry's contribution to the national economy, the Indonesian government has created the National Construction Services Development Board (LPJK) which provides research, training and registry services in the construction sector (Supriadi and Sui Pheng 2018).

Workers skills gap. A major issue in the Indonesian construction sector is the skill gap of workers in the industry (Oxford Business Group 2019). 60% of construction workers are semi- or non-skilled, 30% are classed as skilled workers, and 10% certified as professionals. As the Indonesian construction law only allows certified professionals and skilled workers to work in construction projects, some companies rent worker certificates from other regions – in particular from Java – when they bid for a project. However, when they are awarded the contract, they hire local workers without any certifications (Abduh and Pribadi 2014). The companies hiring non-certified workers include those involved in community building projects, or private businesses involved in constructing housing or shops. However, also in official government construction projects, non-certified workers are employed. An additional human resources challenge is that the Construction Services Law No. 2 (2017) favours Indonesian nationals for positions in the construction sector, but as there is a shortage of local construction workers, foreign workers are often employed instead (HFW 2019; Supriadi and Sui Pheng 2018).

A few years ago, the National Construction Services Development Board called on the government and the private sector to implement a policy that requires construction workers to have a certificate of competency. Law 2/2017 on Construction Services implemented this request, requiring every construction worker to have a Certificate of Occupational Competency, obtainable through successful completion of a competency test (PwC 2017). This is an ambitious goal, given that out of the estimated 7.7 million construction workers in 2017, only around 10% (702,279 workers) were certified. Further, a study has shown that people with low education levels have only limited access to further education opportunities and certification courses (Allen 2016). To address the short-

age of certified construction workers, the government ran the Accelerated Construction Training Program from 2010–2014 to provide training and certificates to 3 million construction workers (Abduh and Pribadi 2014). On a local level, the Trade and Industry Agency in East Java further provides annual capacity building for businesses, in particular SMEs (Interview, Trade and Industry Agency, East Java, 01 June 2020). Law 2/2017 on the Certificate of Occupational Competency only had limited effects. While many certifications have been obtained since its issuance, most construction workers in Indonesia do not know or do not care about the existence of the regulation. They are still able to find work, and the certification fee of Rp. 3,000,000 (187 EUR) is by many considered too expensive. The lack of access to training and thereby certification means that many construction workers are denied the advantages that come with a certificate, namely legal recognition and protection, higher remuneration and a health insurance (PwC 2017).

Social and labour issues. The legal framework in Indonesia foresees construction contracts to include provisions on worker protection, health and safety, social security and environmental protection (Rahmansyah 2020). However, the sector is not free from social and environmental issues. Wages in construction highly differ between the diverse regions of Indonesia. In Jakarta, a skilled worker can earn Rp. 100,000 (6.27 EUR) per day while in Yogyakarta the wage would only be Rp. 40,000 (2.50 EUR) (Suraji 2007). For so-called semi- or non-skilled worker the wage would lie below that.

CO₂ emissions. In terms of moving towards a more climate-friendly construction industry, existing literature has amongst others identified the following two barriers: first, the Indonesian government does not provide the industry with enough regulatory and policy support in planning greenhouse gas emission reductions and developing new standards. Second, existing regulation prohibits certain innovations from gaining ground. For example, the opportunities for substituting clinker with domestic fly ash for producing cement are limited because the law prohibits the purchase or import of hazardous and toxic materials, amongst which fly ash (Panjaitan et al. 2018). The Indonesian government has however made efforts towards more sustainable construction. An interviewee from the Ministry of Environment and Forestry explained that the Ministry issues certifications for environmentally friendly and low-carbon construction building materials,

coordinated by the Environment Standardization Center (Interview, Ministry of Environment and Forestry, 01 June 2020). In Presidential Regulation No. 22 regarding General Planning for National Energy (2017), the government lays out that rooftops of government and luxury apartment buildings need to be covered by photovoltaic panels by 30% and 25% respectively (HFW 2019). Surabaya further has a Green City Master Plan and Local Action Plan for reduction of greenhouse gas emissions in East Java (Amellina et.al. 2016). And while there are no regulations on low-carbon buildings in Indonesia, buildings can get a certificate for environmental friendliness under Minister of Environment Regulation 8/2010 (Supriadi and Sui Pheng 2018).

Localisation. The Indonesian construction sector suffers from a lack of localisation and use of local companies for projects. This is due to an excessive intervention from the big national contractors in local district projects, a lack of capacity building for local contractors, and vertical integration practices of some state-owned enterprises (Abduh and Rahardjo 2013). The lack of localisation also applies to the heavy equipment sector. The construction industry consumes around 13–20% of heavy equipment sold in Indonesia. The industry uses a lot of re-conditioned equipment, with 65 companies in the country providing such equipment. However, the number is decreasing because of import restrictions on used equipment (Abduh and Pribadi 2014). Only 30% of heavy equipment is made by the local industry, using up to 50% local materials, while 70% of equipment is imported (Abduh and Pribadi 2014).

The Ministry of Public Works has made efforts however to improve construction supply chains in Indonesia, including forcing large-size companies to partner with local companies, promoting specialisation of small- and medium-sized contractors, and promoting an environment conducive to subcontracting (Abduh and Pribadi 2014). The government also provides financial incentives for companies to favour local content and local value addition and beneficiation. Under the Investment Law, for example, companies can receive fiscal incentives if they employ a large number of workers, invest in a remote or deprived area, cooperate with micro, small or medium-sized enterprises or cooperatives, use locally produced goods or equipment, or work on a project related to environmental sustainability (Rahmansyah 2020). In terms of competition with foreign companies, Indonesian actors are favoured over foreign ones in the legislation. For

example, according to Construction Services Law No. 2 (2017), foreign entities are not allowed to work in the construction sector unless they have an office or a legal entity in Indonesia and cooperate with an Indonesian company. In addition, the majority of workers hired must be Indonesian citizens, including the head of the office (HFW 2019).

Material provision. The government, through the Center for Investment Resources in the Construction Development Agency, Ministry of Public Works, started a project on harmonising construction supply chains in 2012, aiming at guaranteeing provision of materials for the construction industry and promoting the autonomy and efficiency of the national construction industry (Abduh and Pribadi 2014). Indeed there are issues of domestic provision of construction materials. The Indonesian construction sector suffers from a lack of information on the demand of materials, with details on quantity, quality, location and time (Abduh and Pribadi 2014; Supriadi and Sui Pheng 2018). Not only in the cement industry as described above, but also in other construction supply chains the high cost of material purchasing has shown to be a challenge (Abduh, Soemardi, and Wirahadikusumah 2012). Before the government does not strengthen efforts to reduce raw material prices, self-sufficiency in construction materials will be difficult to achieve (Oxford Business Group, n.d.). An interviewee from the Ministry of Environment and Forestry said that the main issue in the construction raw materials sector is the lack of standard prices. Prices for materials change quickly if there is a change in fuel prices or a monetary crisis. There is therefore no predictability of prices for actors in the value chain. The interlocutor also mentioned the competition between local construction raw materials and imported materials as a challenge, not only in terms of price but also in terms of quality because of a lack of a national quality standard (Interview, Ministry of Environment and Forestry, 01 June 2020).

3.4. Analysis of market barriers and opportunities

There is not enough data for an in-depth analysis of market barriers and opportunities at this stage, but the following elements have been identified as requiring further research in the field and could provide some early leads.

GENERAL BARRIERS

In some developing countries, the national quarrying and aggregate extraction industries are not strong enough to meet domestic demand, creating a need for import. Another main barrier to maximising the use of industrial minerals for local development is the lack of formalisation and the disregard for the sector's potential (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung 2010; Hilson 2016). Local value addition is often not very developed due to diverging interests and a focus on exports and profits. Insufficient domestic production and the need for import does not seem to be such a pressing concern in India or Indonesia according to the information reviewed, but widespread informality has been found in both countries across construction raw material value chains and is an important market barrier to consider.

If local value addition shall be environmentally friendly and work in a low-carbon economy it needs to be accompanied with efficient and environmentally friendly processing and recycling technologies, as well as the required competencies to use them (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung 2010). How much such technologies and competencies are available or not in India and Indonesia and the selected metropolitan areas specifically will be studied in the second research phase.

INDIA

Data paucity and inaccuracy is the norm, as is partial implementation of laws and regulations. Any recommendations will have to be doubly resilient to offset these issues.

Materials acceptance (of fly-ash brick and M-sand) by builders and final users has emerged as a key concern for their adoption.

The use of gypsum in the manufacture of gypsum board (drywall) could represent an opportunity for local value addition but information on its production is conflicting.

Given India's construction sector reliance on migrant labour the impacts of the SARS-CoV-2 triggered urban to rural exodus, if any, should be considered.

The interdependences made possible by cement and steel manufacturing waste products could offer

further opportunities in the manufacture of alternatives to bricks (fly-ash) or Portland cement.

Quarries, brick kilns, and sand extraction sites offer employment and a lifeline to tens of millions of Indian. And while riddled with horrific issues (forced labour, worst forms of child labour, massive environmental impacts, etc..) they nevertheless generate some level of income to a substantial percentage of India's most vulnerable populations. Opportunities should be carefully considered so as not to impact the most vulnerable negatively.

INDONESIA

Indonesian construction companies are facing increased competitions from foreign companies, from China, Japan, South Korea and India. Chinese companies in particular are taking over infrastructure projects. However, the government has undertaken efforts to protect the domestic construction sector from foreign companies (see below). Also workers in the construction sector are sometimes foreign, because of an apparent shortage of local workers.

Competition with foreign companies also exists in the cement industry. Due to the high raw materials prices within Indonesia, the domestic cement industry is often not competitive against cheap foreign imports from China.

It would be interesting to find out why gypsum is not produced to a relevant extent in Indonesia, despite confirmed reserves across the country, including East Java. The mineral is almost to 100% being imported to the country, despite efforts since late 1990s to produce more domestically.

The Indonesian construction sector is dominated by small-sized companies, but they only receive 15% of construction projects in terms of value. This is because large national companies work also on local district projects and because there is a lack of capacity building for local contractors. The government is however undertaking efforts to change this situation, by promoting local content rules and providing incentives for large companies to work with local and small companies.

The Indonesian government has shown efforts to promote local value addition and domestic mineral use as well as Indonesian businesses and communities' participation in the mining sector. Local content requirements are strong in the country and an export ban on

certain raw materials has aimed at promoting stronger in-country processing. However, export bans such as this can have negative side effects, as exemplified by increased sand smuggling.

The Indonesian construction material supply chain is fragmented and characterised by ad-hoc relationships, low productivity, disputes, cost and time inefficiencies. The government has made efforts however on harmonisation of those supply chains. This is important as the country is also struggling with getting raw materials to remote areas because of a lack of infrastructure.

As outlined above, cement has a low utilisation rate in Indonesia as domestic production and demand do not match. Large producers leaving the market therefore can however open opportunities for local companies.

The construction value chain is riddled with informality. At the downstream end, 90% of workers in construction are not certified, even though having a certificate is now a legal requirement for working in a construction project. Getting the certificate is costly however and companies avoid those regulations and hire unskilled workers for less salary and social protection. At the upstream end of the value chain, 90% of ASM miners are considered illegal by the government. It is difficult to obtain legal status as an ASM business. This informal sector is prone to social and environmental issues, as it is poorly regulated and monitored. Linked to this informality is the fact that there is no dedicated government unit responsible for ASM, that sub-national governments do not have the human resources and capacity to monitor mining activity adequately and that they do not coordinate enough with the national government. There is also a lack of data the government has on informal and small-scale actors.

The lack of formality in the sector can have very material effects. Low quality bricks produced in the informal sector – linked to the burning temperature and kiln construction – and the lack of regulation around that have for example led to the production of bricks that provide poor earthquake safety.

Quarries, brick kilns, and sand extraction sites offer employment and a livelihood to many people in Indonesia. And while riddled with many negative issues (forced labour, worst forms of child labour, environmental impacts, etc..) they nevertheless generate some level of income to some of Indonesia's most vulner-

able populations. Opportunities should be carefully considered so as not to impact the most vulnerable negatively.

Given the importance of migrant labour in Indonesia, the impacts of the SARS-CoV-2 on urban to rural exodus and therefore on the construction value chain, if any, should be considered.

Glass waste in Indonesia is currently not widely used for recycling and further processing. There is therefore potential for more recycled glass use in concrete production, road construction or other uses in the construction sector.

Indonesia's brick making industry is largely traditional. For them, using waste material for brick production, or using more modern kiln systems to reduce CO₂ emissions are things not easily accessible.

In the area of Surabaya, cement plants are allowed to use industrial waste as raw materials, which is pos-

itive from a climate change perspective. Indonesian concrete manufacturers are already using fly ash to reduce emissions and waste from power plants, and to reduce their material cost – as using fly ash means they need less cement. However, high quality coal and therefore fly ash is becoming scarce in the country, and regulation prohibits the import of hazardous and toxic materials such as fly ash. Therefore, concrete producers use lower quality fly ash which leads to lower concrete strength and therefore quality issues.

Critics have said that the Indonesian government is not proactive enough on greenhouse gas reductions in the construction industry through the implementation of standards, policies and regulations. However, certifications exist for low-carbon construction materials or environmentally friendly buildings. Surabaya seems to be at the upper end of sustainable cities in Indonesia and seems perceptible for projects and efforts that aim at lowering carbon emissions in the construction industry.

4. Research gaps

4.1. General research gaps

The analysis of market barriers and opportunities in this report is kept general and often based on country-wide information. The second phase of research therefore requires more work on mineral- and geographically-specific market barriers and opportunities, including market linkages and their efficacy, local market conditions, market access, the impact of the regulatory and policy framework, the capacity and resources of institutions, access to resources, technology, the situation of formality, quality and quantity requirements and standards, as well as socio-economic, environmental and cultural factors.

A chapter on lessons learned from previous projects on climate-mitigating actions in the construction value chain will further be added, following in-depth consultation with identified stakeholders.

The potential analysis has been omitted from this report as field research is needed to gather more specific information about the value chains in the two metropolitan areas. The field research will also seek to consult local stakeholders on opportunities and potentials for local value addition and further development of local value chains. The results of this consultation will form part of the potential analysis, which will provide the following in the final report:

- ▶ Models for five promising value chains (take into account the climate impact of proposed measures, with the aim of promoting climate-smart approaches)
- ▶ At least five approaches (in total) to overcome identified barriers (take into account the climate impact of proposed measures, with the aim of promoting climate-smart approaches)
- ▶ At least five approaches (in total) to create more local value addition (take into account the climate impact of proposed measures, with the aim of promoting climate-smart approaches)

4.2. Research gaps India

EXTRACTION AND RECYCLING

Information on number and size of known deposits is not available as State-level agencies are in charge of preparing geological maps and have put little effort into it.

Information on profits, taxes, actors (companies and their sizes) and workforce are only available in the broadest sense through desk review and remote interviews. Interviews with supply chain participants will be required to collect this information.

Available secondary information on relevant regulations and policies does not include information on their level of implementation. Interviews with supply chain participants will be required to identify the regulations and policies that actually impact the supply chain, in particular in the case of informal operators.

PROCESSING AND MANUFACTURING

Description of the activities taking place during the various processing and manufacturing stages are generally non-existent, with a few exceptions, as all available reporting centres on impacts or contributions. Collecting this information will require the visit of operating processing and manufacturing units.

Imports are limited and even the machinery used in the exploitation, processing and manufacturing is mostly indigenous (based on the few youtube videos that could be consulted) shifting value addition even more towards the local level seems difficult. Generating additional revenue through export will run against other issues as extraction is already taking place at a non-sustainable rate and low volume/weight to value ratio will mean that the areas that could be producing for export will be limited to those with close proximity to the border or a harbour.

Information on pricing, profits, taxes, actors (companies and their sizes) and workforce are only available in the broadest sense through desk review and remote interviews. Interview with supply chain participants will be required to collect this information.

Available secondary information on relevant regulations and policies does not include information on their level of implementation. Interview with supply chain participants will be required to identify the regulations and policies that actually impact the supply chain.

Information on the non-LSM limestone and supply chains supplying other industries that cement and steel making is very limited. Interview with supply chain participants will be required to identify the supply chain articulations of this more “unorganised” production.

TRADING AND TRANSPORTING

Information on this section is excessively rare. Interview with supply chain participants will be required to collect this information, including on actors, formality, workforce, pricing, profits and taxes, but also environmental, health and safety and social issues.

END USAGE

Available secondary information on relevant regulations and policies and climate change mitigation actions does not include information on their level of implementation. Interview with supply chain participants will be required to identify the regulations and policies that actually impact the supply chain.

Information on pricing, profits, taxes, actors (companies and their sizes) and workforce are only available in the broadest sense through desk review and remote interviews. Interview with supply chain participants will be required to collect this information.

Satisfactory relevant and specific information, outside of broad statements, on market demand has not been identified. Most of the information found centres on the demands of the big construction companies operating in the centre of the Metropolises. Information on either the adjacent urban sprawl or that is Delhi NCT specific could not be identified. Circulating a questionnaire to representatives of the various builders’ associations could possibly be a way to collect the required information.

4.3. Research gaps Indonesia

EXTRACTION AND RECYCLING

The desk research could only provide information on production in form of mining and quarrying as well as recycling in a broader country context. There are particular information gaps on dimension stones and crushed rock dissected by rock type. Interviews with supply chain participants and provincial and local government representatives will be required to collect more information about the specific extraction and recycling situation in the metropolitan area of Surabaya, including information on deposits, production, pricing, profits, taxes, actors, formality and workforce. Information on recycling is particularly scarce.

Information on import and export of the selected materials is extremely scarce. Whether this stems from the fact that they are rarely imported or exported, or just from a lack of information readily available is a question that needs answering during the field research phase.

Information on environmental, health and safety and social issues as well as climate-mitigating actions in the extraction and recycling stage in the particular context of the metropolitan area of Surabaya needs to be collected through interviews with supply chain participants, local government and civil society.

The Ministry of Environment and Forestry, according to an interviewee from the Directorate General of Prevention of Environmental Impacts of Business Activities, does not have data on the environmental impact of small- or medium-sized businesses. This data must be obtained from the provincial or district environmental agency.

PROCESSING AND MANUFACTURING

Descriptions of the specific activities taking place during the various processing and manufacturing stages as well as information on actors, workforce, formality, pricing, profits and taxes are not readily available for the metropolitan area of Surabaya. Other materials might be added to the analysis following findings from fieldwork, adding to the current focus on bricks and cement. Further, finding information about the value chains of other raw materials used for the production of those manufactured goods requires field research. Collecting this information will require the visit of operating processing and manufacturing units in the area.

Information on environmental, health and safety and social issues as well as climate-mitigating actions in the processing and manufacturing stages in the particular context of the metropolitan area of Surabaya needs to be collected through interviews with supply chain participants, local government and civil society.

TRADE AND TRANSPORTING

Information on this section is excessively rare. Interview with supply chain participants will be required to collect this information, including on actors, formality, workforce, pricing, profits and taxes.

Information on environmental, health and safety and social issues as well as climate-mitigating actions in the trade and transporting stages in the particular context of the metropolitan area of Surabaya needs to be collected through interviews with supply chain participants, local government and civil society.

END USAGE

No information has been found specifically on the construction sector in the metropolitan area of Surabaya. Interviews with construction sector actors and

local government are required to collect data on actors, material demand and use, type and size of construction projects, formality, workforce, profits, taxes and pricing. Circulating a questionnaire to representatives of builders' associations could possibly be a way to collect the required information.

Information on environmental, health and safety and social issues as well as climate-mitigating actions in the construction sector in the particular context of the metropolitan area of Surabaya needs to be collected through interviews with supply chain participants, local government and civil society.

REGULATION AND INSTITUTIONAL CAPACITY

Information on provincial or regency-level regulation, policies and institutional capacity must be added in the subsequent research phase. Available secondary information on relevant regulations and policies does further not always include information on their level of implementation. Interviews with supply chain participants will be required to identify the regulations and policies that actually impact the supply chain, in particular in the case of informal operators.

5. Field research plan

In order to close the research gaps mentioned above and in particular collect more information on the local value chains in the two selected metropolitan areas, the next stage of the project involves field research with various components.

5.1. Preparations

The preparation of the field work will involve finalisation of the research tools (see below) and training of the field researchers (2 per country) on research ethics, the research tools and general methodological considerations.

The preparation also includes logistical organisation including organising transport, setting up meetings as far as possible, defining the itinerary and preliminary selection of sites (sampling). These things are always subject to change and require flexibility from the research team during the research phase. Previously selected sites or interlocutors might not prove to be available or relevant, and new ones might be found during the course of the field research.

The selection of extraction, processing, manufacturing, trading and construction sites and companies involved across all steps of the value chain will follow certain criteria: the research aims at a wide geographical coverage within the defined areas of interest, purposive sampling will be used to focus the research on intensive, contentious or previously neglected activity, and snowball sampling will be used to follow referrals and suggestions by previously interviewed supply chain actors. As the study has a strong value chain approach, the selection of sites and actors to survey and interview will also follow the actual material flows in the study area. Materials are thereby followed if feasible through the value chain, from extraction until manufacturing and the construction site. The sampling of participants at the selected sites and companies will follow both the methods of snowball sampling – in order to reach key informants – and purposive sampling to cover a

variety of roles, ensure that both women and men are interviewed, and to ensure participation also of vulnerable people. Apart from supply chain participants, the researchers will also speak with government representatives, industry association representatives and civil society organisations as well as community representatives.

In order to make a preliminary choice of research participants, a stakeholder mapping matrix will be filled in prior to the research phase, and updated accordingly during it. The matrix will include:

- ▶ Value chain participants in the formal and informal sectors: Mining/quarry companies and workers, processing companies and manufacturers and their workers, transport businesses, traders and sales-people, construction companies and their workers, other customers of raw materials, exporters and importers.
- ▶ Actors that influence the value chain or are affected by it: industry representatives and associations, government officials from trade, commerce, industry and mining authorities, civil society representatives, local communities.

5.2. Activities

Two researchers per country will spend around three weeks in the metropolitan area conducting the following activities:

- ▶ Testing of the field research tools with a few participants
- ▶ Refinement of the research tools based on the testing results
- ▶ Conducting interviews with national government and local government stakeholders, complementing and following up on remote interviews;

- ▶ Conducting interviews with industry representatives and civil society representatives ;
- ▶ Conducting site assessments and interviews at mines/quarries, processing centres, recycling centres, traders, transporters, manufacturers, and construction sites;
- ▶ Obtaining additional public data and statistics to supplement, triangulate and extrapolate data collected in the field;
- ▶ During the field work, and shortly afterwards, the researchers will also run the results of the potential analysis and the suggested options past experts and key stakeholders to sense check the ideas put forward by the project team.

The following table shows how the new information will help to close the research gaps identified above:

Information	Interviews			Site assessments/ interviews	Public data and statistics
	Government stakeholders	Industry representatives	Civil society representatives		
Specific market barriers and opportunities	✓	✓		✓	
Lessons learned	✓	✓	✓		
Potential analysis	✓	✓	✓	✓	✓
Profits, pricing and taxes	✓	✓		✓	✓
Companies and workforce	✓	✓		✓	✓
Number and size of deposits	✓	✓		✓	✓
Locations of extraction, processing, manufacturing, construction	✓	✓		✓	✓
Processing and manufacturing activities and conditions		✓		✓	
Exact structure of local value chains		✓		✓	
Trading and transport		✓		✓	
Market demand for materials		✓		✓	✓
Local social and environmental issues	✓		✓	✓	
Climate mitigating actions		✓		✓	
Import / export	✓	✓		✓	✓
Implementation of regulation		✓	✓	✓	
Capacity of institutions	✓	✓	✓	✓	

5.3. Research tools

The research tools developed for the field research are the following (subject to change in the preparatory phase):

- ▶ Semi-structured interview guide for government stakeholders
- ▶ Semi-structured interview guide for industry representatives
- ▶ Semi-structured interview guide for civil society representatives
- ▶ Site assessment questionnaires for the various stages of the value chain – this will likely be forms on the software Kobo which allows for mobile data collection through the app ODK Collect

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