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Improved Methodology for Monitoring the Impact of Mining Activities on Socio-Economic Conditions of Local Communities

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Keywords

iron ore mining; socio-economic impact; impact assessment; environment; monitoring; improved methodology.

Improved methodology for monitoring the impact of mining activities on socio-economic conditions of local communities

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Abstract

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1. Introduction

India is endowed with abundant mineral resources [1]. The state of Karnataka in India has, within its boundaries, two major mineral belts of the country – the southern and the south-western. Both of these belts contain vast deposits of iron ore, making Karnataka the state with the highest reserves of iron ore in India [2].[1] Within Karnataka, the richest deposits of iron ore are found in the Ballari district.

1.1. Ballari – the mining capital

It is no surprise then that iron ore mining has, since the beginning, formed the backbone of the economy of Ballari. Mining operations picked up pace in Ballari after the National Mineral Policy in 1993 called upon the private sector to participate in mining activities. With the commissioning of the Jindal steel plant at Vijayanagar in 1997, it was anticipated that the status of Ballari as an industrially backward district will transform. Further impetus was received by the mining sector in 2000 when the Karnataka State Mining Policy outlined an export-oriented development strategy. Soon, several acres of mining area, previously reserved for the state, were opened up to private players. Finally, iron ore demand coming in from Beijing in the years leading up to the summer Olympics of 2008 led to an unprecedented boom in mining operations of the district. In 2008, it was estimated that the district had close to 1,000 million tonnes of iron ore deposits [3]. Iron ore production in the district increased from a mere 6.87

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[1] As per NMI database based on the UNFC system, the state of Karnataka ranks the highest in terms of combined reserves of hematite (2,467 million tonnes) and magnetite (7,802 million tonnes), the two principal iron ores.

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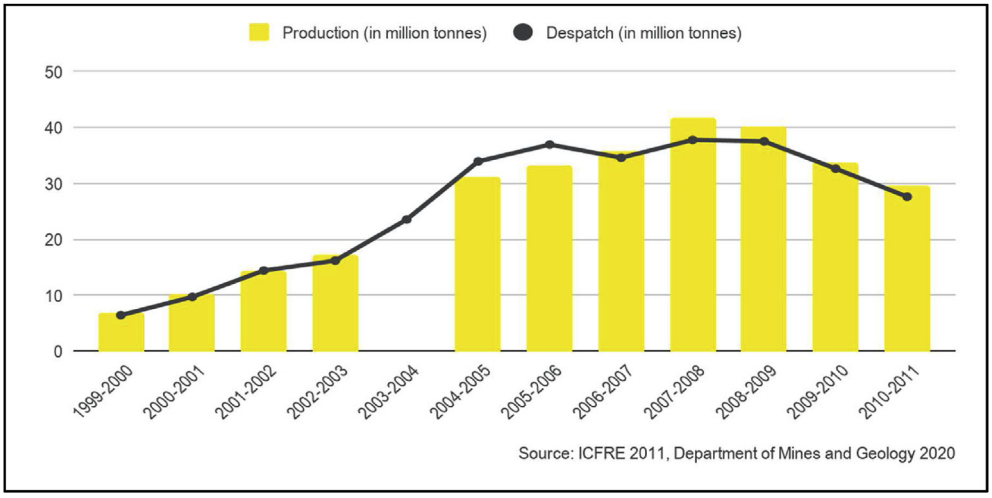

Fig. 1. Year-wise data on iron ore production and dispatch in Ballari district.

million tonnes in 2000 to 33.69 million tonnes by 2010 (Fig. 1). The cost of production averaged at INR 150 per tonne of iron ore, and given that royalties that needed to be paid to the state government remained as low as INR 16.25 per tonne, the profit margin for private players was immense [4].

Predictably, the pace and extent of growth of the mining industry in Ballari soon resulted in a powerful nexus between private mine and industry owners and the local politicians. This led to allegations of large-scale corruption and profiteering through rampant illegal mining activities in the district. Such allegations began to draw significant attention of media organizations as well as civil society representatives, compelling the state government to proactively address the issue. Consequently, in 2007, under Section 7 (2 A) of the Karnataka Lokayukta Act, 1984, the government ordered the Lokayukta to investigate and submit a report with specific recommendations to combat large scale irregularities in the way the state's mineral wealth was being exploited. The Lokayukta was also directed to initiate action against public servants, including ministers, who might have acted in collusion with private parties.

The Lokayukta report confirmed all claims of illegal mining activities in the district and recommended a ban on all trades of iron ore, including export, asserting that the mineral should be reserved only for domestic consumption. However, the situation did not improve, prompting Samaj Parivartana Samudaya, a non-governmental organisation, to file a writ petition before the Supreme Court of India in 2009 under Article 32 of the Constitution. In response, the Court appointed a Central Empowered Committee (CEC) to look into the matter. It also ordered the Indian Council of Forestry Research and Education (ICFRE) to carry out a macro-level Environmental Impact Assessment (EIA) of Ballari district in collaboration with the Forest Survey of India (FSI) and Wildlife Institute of India (WII) and in consultation with the Ministry of Environment and Forest (MoEF) (now Ministry of Environment, Forest and Climate Change (MoEFCC)) and domain experts and specialists. The CEC report, yet again, confirmed allegations of illegal, irregular and environmentally unsustainable mining activities in the district, leading to the Supreme Court, in 2011, ordering complete suspension of all mining activities in Ballari with immediate effect.

Since then, keeping in mind the needs of the domestic steel industry and loss of livelihood for many of those dependent on mining and allied sectors, the Supreme Court gradually allowed for re-opening of mines. However, resumption of mining activities was strictly made dependent upon mandatory submission of Reclamation and Rehabilitation Plans (R&R Plans)[2] for the mine affected areas, to the satisfaction of the CEC. In addition, a maximum permissible limit on annual production (MPAP) for mining in the district was imposed.

The Supreme Court of India also constituted a Special Purpose Vehicle (SPV) to implement a Comprehensive Environment Plan for the Mining Impact Zone (CEPMIZ) to manage the large-scale

[2] Mine lease-wise R&R plans were to be prepared by the Karnataka government, which outsourced the task to the Indian Council of Forest Research and Education (ICFRE).

environmental degradation caused by mining activities in the district. The funds for the SPV to implement mitigative measures were to partially come from the sale of iron ore minerals. As on 30.11.2019, the SPV has an accumulated deposit worth INR 14,369 crore. Thus, over time, mining operations have resumed in almost 36 leases across the district, with a total output of 32 million tonnes against an approved capacity of 35 million (Fig. 2).[3]

Despite the continued upward trajectory of the mining industry, as evident from Figs. 1 and 2, Ballari has remained an underdeveloped district and the state of the people in the district has remained deplorable. Though mining emerged as a powerful industry in the district even after the challenges posed by a temporary ban, consequent improvements in the socio-economic indicators of the local communities have been disproportionate and lopsided. In 2005, Ballari ranked among the bottom 10 districts on Karnataka's state human development index, even though its per capita NDDP (Net District Domestic Product) was increasing [3]. It was estimated in 2008, that more than 45% of the district's population lived below the poverty line [5].

In fact, such a situation is not just unique to Karnataka. In Jharkhand, Chhattisgarh and Orissa as well, per capita incomes are lower than that in states which are poorer in mineral wealth [5]. This raises questions on the mining industry's claim that it can promote growth in backward areas by decreasing the level of poverty. Such a phenomena has been dubbed as "resource curse" by researchers and the proof of the same exists in the fact that out of the 50 major mining districts of the country, 60% of them are also the most backward districts of India [5–8].

Mining activities not only adversely affect the surrounding environment by causing erosion of biodiversity and contamination of surface water, groundwater and soil, it also impacts the health, safety, and well-being of those living in mine-affected areas. Reports have suggested that there has been a sharp increase in mining-related diseases in the surrounding areas with acute diarrhea and respiratory diseases making up for 42% of the total health related problems in mining areas of Ballari, Hospet and Sandur [9]. Similarly, there has also been an increase in the number of road accidents in the area resulting from poor road conditions and increased density of heavy vehicles on the roads as a direct result of iron ore transportation.

It is not unreasonable then that public acceptance of mining activities remains low and the mining industry lacks a social license to operate. It is in this context of mining and its linkage with poor development outcomes that, alongside studying the environmental impact of mining, evaluating its impact on the living conditions of the local population and their socio-economic well-being becomes crucial.

2. Review of literature

The literature review performed for the purposes of this study began with a theoretical exploration of

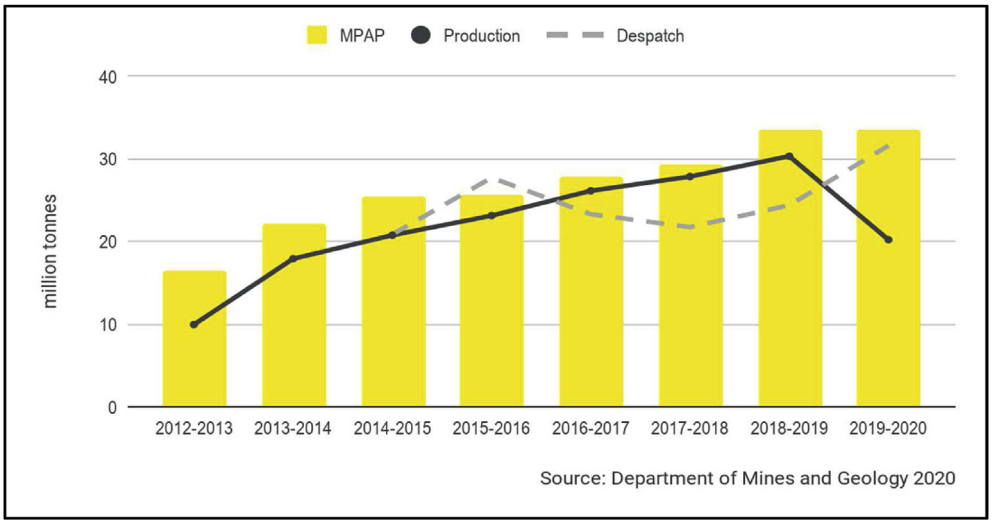

Fig. 2. Year-wise data on iron ore production and dispatch in Ballari district post lift of mining ban.

[3] Personal communication received from the office of Deputy Director & Director, Mines and Geology, Government of Karnataka.

the concept of socio-economic impact assessment, which is detailed in the following sections. Further, literature on the impact of mining activities in India was studied extensively. The search for relevant literature was conducted through the web search engine Google and the academic database Google Scholar. The keywords used for the search were "mining," "environment," "social impact," "socio-economic impact," "India," and "Ballari". Studies were chosen within the timeframe from 1998 to 2018, to cover a span of two decades. In particular, the focus was to find out research conducted on consequences of opencast iron ore mining. During such a search, most studies were found to be geography-specific, based in top iron ore producing countries including Brazil, Australia, South Africa, Tanzania and India, among others [10–16]. A secondary search was also conducted with the words "employment," "infrastructure," "poverty," 'education," and "health," related to mining. The rationale behind such a search was to study the mitigative and welfare measures taken by project proponents concerning the revenue being generated from mining operations.

Several researchers and industry experts have extensively studied the nature of mining operations in and around the Ballari district and have attempted to describe their impact. Kommadath and Rath [17] have captured in depth the sectoral shift of the economy of Ballari from agriculture to industry and then to services due to the mining boom. One of the earliest studies by Rudramuniyappa [18] highlighted the extent of degradation of agricultural land, deforestation, air pollution, and water pollution caused by mining activities in the Ballari region and the need for effective planning to minimize such an adverse environmental impact. Several other studies have also focused on the impact of iron ore mining on water resources such as on the river Bhadra in Karnataka [19]. Further, the impacts of dust generated from iron ore mines on the health of the workers and local residents and on the agricultural productivity of the area have been studied [20–23]. A detailed study on the impact of mining activities on the ambient air quality in Ballari was done by Patel indicating worrisome levels of several pollutants in comparison to the National Ambient Air Quality Monitoring (NAAQM) limits [24].

Aside from the environmental impact of mining, the socio-economic impact of mining has also been explored by various researchers in a myriad of geographies [25]. Within India, most social impact studies of iron ore mining were focused on Orissa [26–28]. Some related studies discussing themes of displacement, corporate social responsibility (CSR) and women as mine workers have been based in Uttar Pradesh [29], Rajasthan, Goa [30] and Jharkhand [31]. Table 1 presents the selected samples of studies on impact assessment of iron ore mining specific to the Ballari district.

2.1. Problem description

As evident from Table 1, while researchers have extensively studied the environmental consequences of mining, there is a scarcity of research on the socio-economic impact of mining activities on the local population in the Indian context. The secondary priority allotted to studying the social impact of mining activities is also evident in the very process of grant of mining leases, whereby, the mining plan to be submitted by an applicant covers an assessment of the impact of mining on forest, land surface, and environment only. Socio-Economic Impact Assessment (SEIA) continues to form a subpart of the Environmental Impact Assessment (EIA) process.

Within such a process, project proponents seldom gather real-time data to determine and monitor the changes in social and economic indicators in the impact zone as a direct or indirect consequence of mining projects. Secondary data utilized in the assessment report remains outdated and the size and composition of the primary data sample collected remain unrepresentative. The concerns surrounding this aspect have been discussed in detail later in this paper.

On a macro level, the problem also lies with the ineffective utilization of funds allotted to improve mineral districts, such as the District Mineral Fund. Even though multiple initiatives aimed at reform have been launched by the present government at both central and state levels, efficient and targeted implementation of welfare schemes remains a challenge. As observed in Ballari, a Special Purpose Vehicle (SPV) was established following the orders of the Supreme Court; however the schemes for development of the impact zone are not operational on ground.

Thus, weak attempts at improving the social impact of iron ore mining have led to significant public dissatisfaction with the industry.

2.2. Research objective

As highlighted in the preceding section, the paper aims to address the limitations of the socio-economic impact assessment methodology in the

Table 1. Studies on impact assessment of iron ore mining specific to the Ballari district and identified gaps.

Sl. No.	Source	Research	Limitations and Gaps
1	Rudramuniyappa, 2012 [18]	Iron ore mining and its impact on environment in Sandur – Hospet region of Ballari	Qualitative remarks only, no data reflecting the increase in levels of pollution; social impact not covered
2	Hegde, 2004 [20]	Surface and subsurface water pollution due to mining activities in Ballari district	No recommendations on how to mitigate impact, social impact not covered
3	CAG, 2012 [32]	Socio-economic impact of mining in Ballari region	No study on socio-economic indicators related to education, health, and water, sanitation and hygiene (WASH)
5	Kumar et al., 2016 [21]	Water quality assessment in and around Sandur Taluk, Ballari	Social impact not covered
6	Patel et al., 2017 [22]	Impact of mining and related industrial activities on air quality, water quality and noise environment in Ballari region	No comparative study on pre- and post-mining levels; best practices to mitigate impact not covered; social impact not covered
7	Kulkarni and Jayasheela, 2017 [33]	Socio-economic impact of iron ore mining activities around Hospet area in Ballari	No data on specific socio-economic indicators included; no recommendations
8	Kumar et al., 2017 [34]	Assessment of soil loss in Sandur Taluk due to mining activities in and around Ballari district	No data on specific socio-economic indicators included; no recommendations
9	Nayak, 2018 [35]	Study on the socio-economic conditions of mine workers in Ballari	Focus only on mine workers, others under direct and indirect impact of active mining not covered
10	Thimmaiah et al., 2012 [36]	Economic analysis of environmental pollution and health impacts caused by mining in Ballari-Hospet region	No analysis on socio-economic indicators other than health
11	Basavaraj, 2014 [37]	Evaluation of social costs of mining in Ballari	Indicators related to Education and Health not covered
12	Kommadath and Rath, 2015 [17]	Impact of iron ore mining in Ballari on economy and labor market	Social impact assessment outside the scope of study
13	Patel, 2017 [24]	Environmental impact assessment of iron ore mining in Ballari region	Social impact assessment outside the scope of study

specific context of iron ore mining in the Ballari district in Karnataka. The current study is directed towards the aim of developing a new methodology for monitoring the social and economic changes that are likely to follow the implementation of mining projects. The paper also attempts to highlight the need for real-time data collection to aid the process of decision making and accurately predict, minimize and mitigate adverse impacts of mining activities on the local population.

3. Study area

A case study of the Ramgad village, located in the Sandur Taluk of Ballari district (Fig. 3) is being utilized. Here situated is the Rama iron ore mine leased out to JSW Steel Limited through the e-auction process. The authors chose Ramgad village, which falls under the impact zone of the Rama iron ore mine, as the study area keeping in mind the level of familiarity with the cultural and social setup of the village as well as interpersonal connections with the locals.

4. Research methodologies

An exhaustive literature review was conducted to support the above problem description. The literature review performed for the purposes of this paper was conducted through the web search engine Google and the academic database Google Scholar. Information was also gathered during personal interactions with Mines and Geology Department officials from the Government of Karnataka. Other secondary sources of information include statutory documents from various governmental bodies such as the Karnataka State Pollution Control Board (KSPCB), Ministry of Environment & Forest (MoEF) and Indian Bureau of Mines (IBM), among others.

To validate the recommendations put forward in this paper, a case study was carried out in 2019 in the Ramgad village in Ballari district wherein the Rama Iron Ore Mines of M/s. JSW Steel Ltd (ML 2621) is located. The village of Ramgad was selected for this study due to the concentration of iron ore mining activities in the region based upon proximity

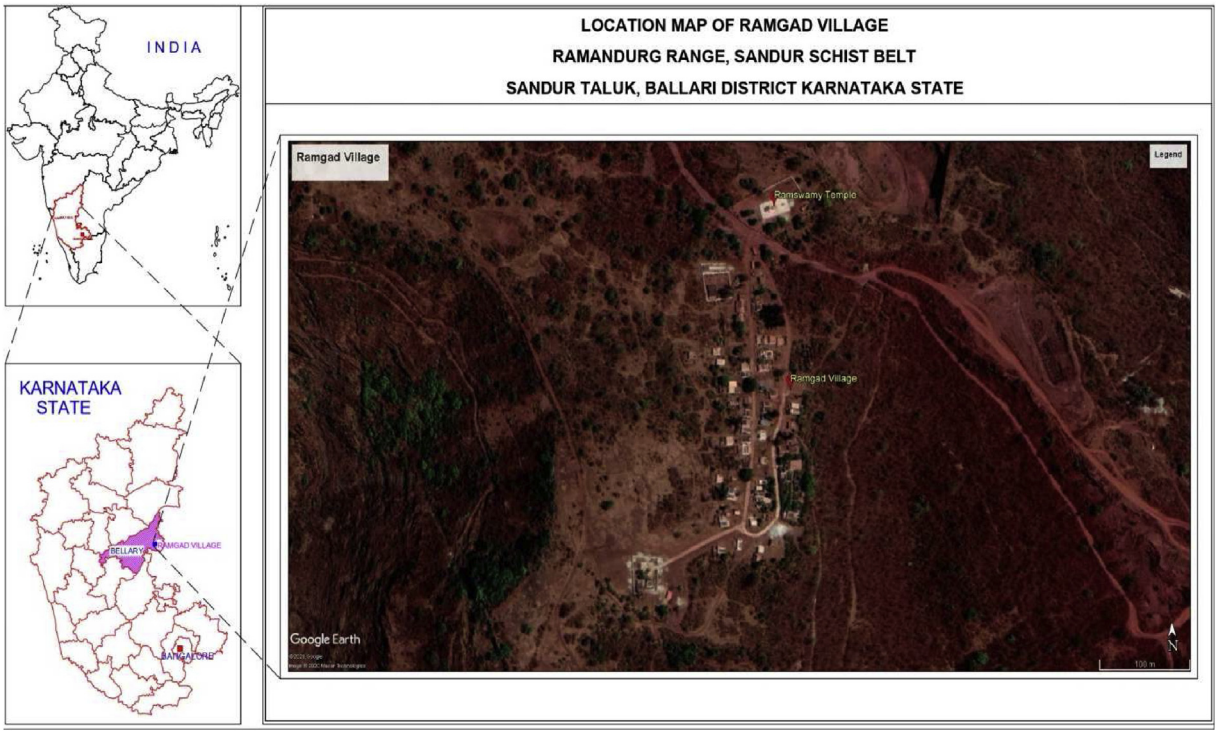

Fig. 3. Location map of the study area.

factor. The village of Ramgad falls within a 0.5 km radius from the mine site.

Primary data collection exercises were carried out in the study area. The primary data was cleaned, tabulated, and compared against the secondary data collected from various sources, including the Census of 2001 and 2011, documents, and reports from the District and Block level offices, National Bank for Agricultural and Rural Development (NABARD) and reports and statutory documents available on the websites of organizations such as the Ministry of Environment, Forest and Climate Change (MOEFCC), Karnataka State Pollution Control Board (KSPCB), Central Pollution Control Board (CPCB), Indian Council of Forestry Research and Education (ICFRE), Indian Bureau of Mine (IBM), and other line departments.

4.1. Data collection

The fieldwork for the case study detailed later in this paper was conducted by the authors' team of four. This team consisted of mining professionals familiar with the local language and social structure of the study area. There was a total of sixteen days of fieldwork during July and August 2019 in the mine-affected village of Ramgad, in addition to four days of focused group discussions and targeted interviews. A closed-ended, structured questionnaire was prepared by the author to collect primary data on relevant socio-economic indicators. A total of 184 responses were obtained.

Specifically, the team requested to meet with key community leaders. At every meeting, five to eight individuals from the village were present. The team took special efforts to ensure interactions with women and youth. The field team made it apparent to all villagers that this study is being conducted for purely independent research purposes, and they did not represent any project proponents.

5. Socio-economic impact assessment

The process of socio-economic impact assessment (SEIA), hereafter SEIA, aims to understand how a proposed developmental project will impact the lives of persons living in the surrounding regions. The scope of SEIA has often been understood to include a study of "all social and cultural consequences to human populations of any public or private actions that alter the ways how people live, work, play, relate to one another, organize to meet their needs, and generally cope as members of society" [38]. While sustainability research has traditionally focussed on the environmental impact of resource extraction, studying the socio-economic

consequences of the same is a relatively new practice [39].

The origin of the practice of Social Impact Assessment (SIA) can be traced back to the 1969 National Environmental Policy Act (NEPA) implemented in the United States [40]. Throughout the 1970s and 1980s the concept further developed formally with contributions from several governmental agencies as well as professors and researchers from leading universities. In 1994, the Interorganizational Committee on Guidelines and Principles (ICGP) issued guidelines and principles for social impact assessment, defining social impact assessment being "predicted on the notion that decision-makers should understand the consequences of their decisions before they act, and that the people affected will not only be appraised of the effects but have the opportunity to participate in designing their future" [41].

The essence of the practice of conducting social impact assessments has been captured in its entirety by Burdge, who says that, an assessment must answer the following questions, "What will happen if a proposed action were to be implemented – why, when, and where? Who is being affected? Who benefits and who loses? What will change under different alternatives? How can adverse impacts be avoided or mitigated, and benefits enhanced?" [42]. Thus, the importance of assessing the social impact of any developmental activity before its initiation is rooted in the notion that the project affected people must be engaged and recognized as key stakeholders in all decision-making processes. Equitable benefit sharing to ensure the socio-economic welfare of the local population is becoming indispensable to the successful operation of an industry.

In the Indian context, the origin of impact assessment practices can be traced back to the notification issued by the Ministry of Environment and Forests in 1994 under the provisions of the Environment (Protection) Act, 1986, which made obtaining an Environmental Clearance (EC) mandatory for developmental projects including mining [43]. Since then, socio-economic impact assessment for all scheduled projects has been carried out as a part of the Environmental Impact Assessment (EIA) process. Environmental Impact Assessment (EIA) has been defined as "a tool used to identify the environmental, social and economic impacts of a project prior to decision-making" [44]. According to Muralikrishna and Manickam [45], "early identification and characterization of critical environmental impacts allow for the environmental acceptability of the proposed developmental project," and EIA is such a tool to aid this process. Impact assessment is also accompanied by suggesting mitigation measures that can be taken by project proponents in case negative consequences for the environment or the society are predicted.

Socio-economic impact assessment in India was also mandated by The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act of 2013, under which all major projects require an SIA to be conducted as well as require the preparation of a Social Impact Management Plan (SMP) [46].

5.1. Methodology of impact assessment

In the case of mining projects, a three-stage procedure is followed, wherein "scoping" and "public consultation" emerge as especially important components. At the "scoping" stage, the Expert Appraisal Committee (EAC) and the State Expert Appraisal Committee (SEAC) "determine detailed and comprehensive terms of reference (TOR) addressing all relevant environmental concerns for the preparation of an EIA report in respect of the project or activity for which prior environmental clearance is sought" [43]. At the "public clearance" stage, concerns of local project affected persons are taken into account and the applicants seeking the environmental clearance are expected to address them, subsequently incorporating changes in the final report.

Project proponents must be aware of the changes their activities might lead to in both primary and secondary zones of impact. Here, the impact is measured both qualitatively as well as in quantitative terms. The area wherein the impacts of mining projects are being determined are classified into the "core zone" and the "buffer zone". While the mine lease area makes up the "core zone," the area within a 10 km radius around the boundary limits of the mine lease area refers to the "buffer zone". Identifying such an impact area by using the proximity criteria enables the identification of the project affected persons.

To ascertain the socio-economic impact of the mining activity, it is essential to study the present status of the people living in the impact area. In specific cases of mining projects, the Ministry of Environment, Forest and Climate Change has also recognized that in order to evaluate the socio-economic impact of a mining project, a prior study on the existing socio-economic status is indispensable [43]. Such a study is usually conducted by utilising baseline data from various sources. Census is conducted throughout India under uniform conditions. Hence, a major source of information is the Census

data. Other sources might include state and central government publications such as the economic surveys, records maintained by local governmental bodies such as municipalities and panchayats, and results of surveys carried out by various research agencies and academic institutions.

In some instances, primary data is also collected by undertaking field visits to villages within the impact area using survey tools such as personal interviews. Participatory Rural Appraisal (PRA) tools and questionnaire-based, pre-structured Feedback Surveys are also used. Such a survey is also conducted with the objective of assessing the views of the local population, their representatives and administrative heads on the proposed industrial project.

The baseline scenario is then superimposed with a projection of the socio-economic changes, both positive and negative, that might occur as a direct or indirect consequence of the proposed operations in the study area. The changes are categorized in terms of intensity, duration, extent, and probability of occurrence.

5.2. Database

To serve as background information for conducting a SEIA study, data on socio-economic profile of the people living within the impact area is gathered. This includes demographic data (area, population, population density, number of households, size of family, average size of households, sex ratio, data specific to socially weaker groups such as the Scheduled Castes and Scheduled Tribes), data related to education (literacy rates), economic data (work force, occupational pattern, pattern of land use, land holding size, cropping pattern, annual income, savings, assets), data related to the availability of drinking water, healthcare, sanitation, electricity, communication and other infrastructural facilities. Alongside, data regarding existing resources in the area, the social structure of the community and public utilities present must also be collected. The presence of public infrastructure such as roads, water supply, drainage, power, sanitation facilities, among others, must also be studied. It is also important here to directly interact with the local people to understand their perceptions of the proposed mining project.

5.3. Limitations and gaps identified

The prioritizing of environmental issues over social aspects in the EIA process has already been touched upon earlier in this paper. The legal requirements are such that a project's social impact is treated much more casually than its environmental aspects. Moreover, even the information gathered on the social aspects of a mining project is met with an insufficient level of analysis. A quick look at any EIA report is enough to contest that the SIA is purely descriptive and looks like a mere repository of data, without any serious analysis of its significance and relevance.

A significant gap is observed in the coverage of secondary social impacts such as displacement, pattern changes in migration in and out of the impact zone, which changes the local social structure, local conflicts within the community as well as between the community and project officials, among others. Besides, there is also a lack of specific mitigation measures suggested for each identified impact. Concerns have also been raised on the level of familiarity of the study team involved in preparing the EIA report with the local socio-cultural structure.

Above all, the EIA process faces a significant data constraint. For example, in the EIA report developed for the Rama iron ore mine (part of the case study later in this paper), most of the baseline data utilized is taken from Census reports of 2001 and 2011. It is reasonable to assert that the socio-economic profile of an area is dynamic and changes rapidly, especially in response to industrialization in the surrounding areas. Additionally, the EIA Report also presents data from a sample survey that covered 120 households within the study area. There is a contention that the sample size chosen for baseline data collection surveys is not representative of the actual population of the study area. In this context, the EIA report presents an outdated depiction of the socio-economic conditions of the study area. Several indicators are inadequate and incomparable due to the lack of single-season data.

Moreover, the impact assessment exercise, even though conducted by a third party, is entirely funded by the project proponent, whose primary motivation is to obtain all statutory clearances. Such a limitation has also been recognized by other researchers where the practice of social impact assessment runs the risk of being reduced to a mandatory, token exercise without strict legal and policy backing [47]. Hence, the EIA report itself can be biased to a great extent since presenting an optimistic baseline scenario would mean a lesser need for developmental work to be undertaken by the industry.

However, the most significant gap identifiable in the assessment processes is that after the EIA report has been presented, there is no real-time monitoring of the measures being implemented by the project proponents for the socio-economic development of the impact area. Merely looking at the

amount of money earmarked under corporate social responsibility (CSR) activities does not guarantee any actual change on the ground. Thus, a transition towards rigorous social impact measurement and monitoring with a greater focus on data gathering is the need of the hour.

6. Case study of Ramgad village, Ballari

To further highlight the extent of the limitations and gaps mentioned above, a case study of the Ramgad village, located in the Sandur Taluka of Ballari district, is being utilized. Here situated is the Rama iron ore mine leased out to JSW Steel Limited through the e-auction process. Since the Rama mine area is spread over forest land and since mining projects fall under Schedule-I of EIA Notification, 1994, an environmental clearance from the Ministry of Environment and Forests was mandatory alongside a forest clearance under the Forest (Conservation) Act, 1980. For this purpose, an Environmental Impact Assessment study was carried out by the project proponents. The final EIA report submitted to concerned authorities utilizes data from Census 2001 and Census 2011 to establish the baseline demographic and socio-economic scenario of all villages within an area of 10 km from the Rama mines. Certain primary data was also collected by those who have formulated the final report, albeit limited in scope. For example, only 20 villagers from the Ramgad village were a part of the Focused Group Discussions held.

To carry out the case study, a comprehensive interview schedule was prepared. Some of the photographs taken during interaction with locals from Ramgad village as part of the case study are shown in Figs. 4 and 5. Household level data was collected by utilizing a detailed questionnaire comprising 28 questions divided into different sections on the demographic profile of the household, the socio-economic status of the household, and the highest level of education attained by the members of the household, among others. Some open-ended questions were also included in the survey to gather an understanding of the villager's perception regarding the mining activity, the effects of mining on their livelihood and surrounding environment, as well as mitigative measures taken by the project proponents.

Fig. 4. The author at Rama iron ore mine, interacting with locals as part of the case study.

Fig. 5. The field team that assisted the author in carrying out the case study with locals from Ramgad village.

As part of the initial analysis, the data presented in the EIA report was compared against the data collected during the case study, and several gaps were identifiable. For instance, based on the latest Census data, the total population of Ramgad village was reported to be 271 persons, with a total of 63 families residing in the village. However, when the field team visited the Ramgad village for this case study in 2019, only 39 families were found to be inhabiting the village. Even though there were 52 pucca house structures, 13 of those were found to be vacant. The population of the village was found to be 182 persons. The above data points towards out-migration from the village between the years of 2011

Table 2. Comparative data on demographic and socio-economic indicators of Ramgad village.

Data	Census 2011	Case study 2019
Population	271	182
Number of males	133	93
Number of females	138	89
Number of children (0–6 years)	37	28
Number of households (HHs)	63	39
Literacy	74.79%	54.94%

Table 3. Socio-economic profile of Ramgad village (Case study 2019).

HHs with electricity	100%
HHs with drinking water	100%
HHs with toilets	2.56%
HHs with cooking gas	84.61%
Medical facilities	Not available
Communications and roads	Not available
Educational facilities	Available
Anganwadi center[a]	Available
Drainage facilities	Not available

[a] Anganwadi is a type of rural child care centre in India.

and 2019. Other issues of differences in data have been captured in Table 2. Further observations from the case study have been presented in Table 3.

7. Recommendations

Overall, compared to the revenue generated from the mining activities in areas surrounding the Ramgad village, the pace of development of the village and the socio-economic conditions of the villagers presently residing in the village are disproportional. Based upon the observations gathered during the field study detailed above, this paper puts forward a novel methodology of both improving the social impact of mining activities in the surrounding areas as well as utilizing technological advancements to accurately measure such an impact.

As evident from the limitations identified in the preceding section, foremost, there is an urgent need to gather real-time data. The paper recommends conducting baseline surveys of all villages falling under the impact zone. A systematic collection of data across various socio-economic indicators can be carried out using a dual-methodology of door-to-door social audit surveys supplemented by aerial surveys using unmanned aerial vehicle (UAV) technology (Fig. 6). Drone-based aerial surveys have enormous potential to collect topographic data of high quality with an accurate measurement, with lesser inputs of time and capital.

Data collected at this stage can be fed into a mobile-based application to be stored on a digital cloud platform (referred to as *Data Halli* in Fig. 7), designed after due consultation with cybersecurity experts. Data submission at this stage must be encrypted and safely transmitted over a private, internal network with strict policies that limit access to, and disclosure of, data. Data will be visualized through a dashboard accessible both on the web and mobile (Fig. 8). A centralized database will counter the practice of formulating projects and policies based upon outdated data and allow

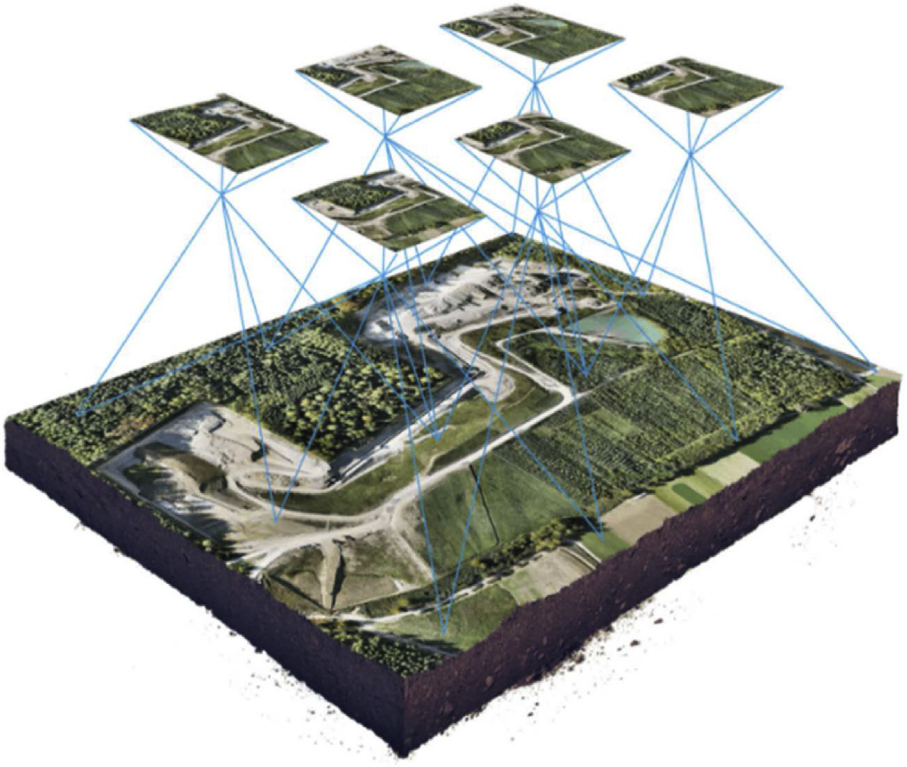

Fig. 6. Data capture by UAV based aerial survey (Source: https://wingtra.com/drone-photogrammetry-vs-lidar/).

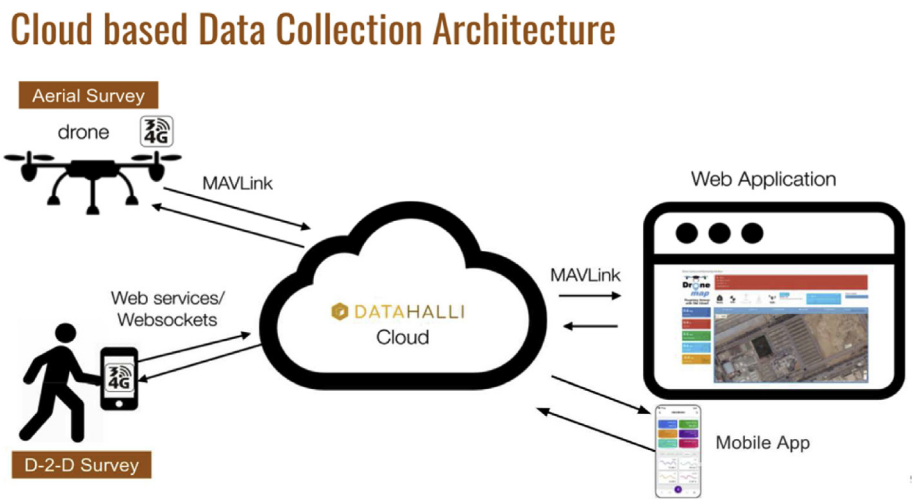

Fig. 7. Architecture of the proposed digital cloud platform.

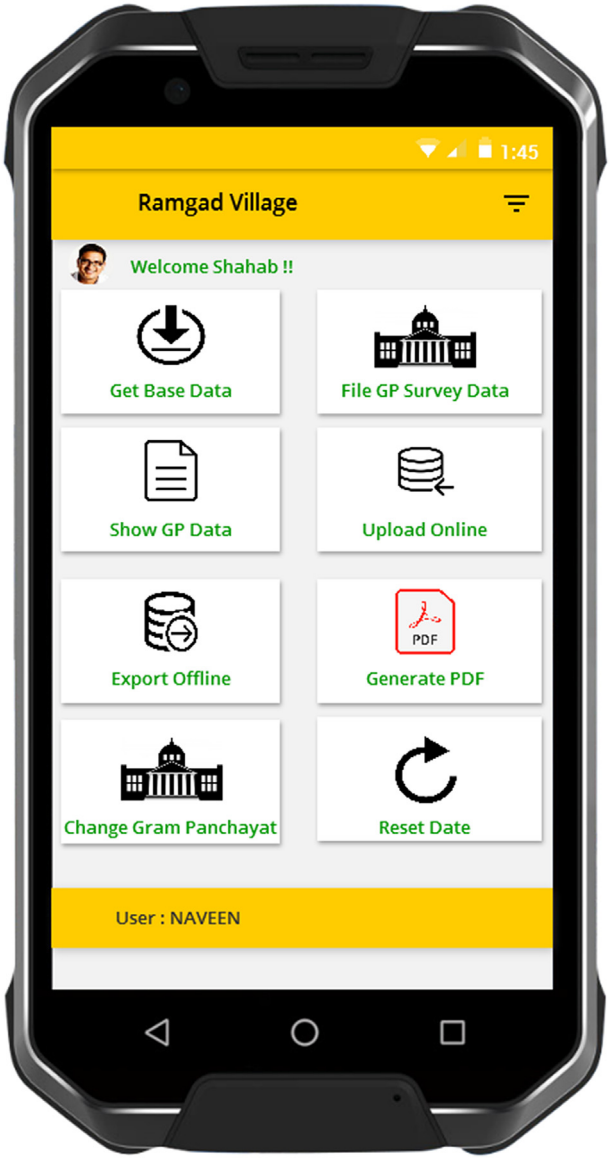

Fig. 8. Proposed application to be operated on hand-held devices for data submission.

baseline data to be more accessible for reference during the impact assessment process. Efforts can be made to update the baseline data for all villages every financial year. At later stages, the database can also be shared in a public domain, such as on a dashboard shown in Fig. 9, which can be synced on a monthly basis. Such a database would be run and managed at a data centre built in each village. The data centre will generate employment for the local youth, who can be trained accordingly to operate the centre.

Data collected through the above methodology will be analyzed by welfare officers and assessment experts to track the impact on various socio-economic indicators over a pre-defined time period. The data can be utilized by the project proponents to design mitigative strategies and subsequently, year-on-year changes in the indicator levels to track progress and undertake course correction. Such analysis can also be utilized to formulate a Village Development Plan (VDP), along similar lines envisioned under the Sansad Adarsh Gram Yojana (SAGY), following thorough quantitative and qualitative analysis. Within each plan, specific targets for socio-economic development of the village area, including infrastructural development, must be set for each year based on the latest baseline data collected. Preparation of such a plan must be a multi-stakeholder process with maximum community engagement for weighing and scoring attributes. Gram Panchayat members, most familiar with the local demography, can be duly consulted to undertake a thorough need-analysis. The findings from the above process will directly feed into the exercise of putting together programmes, targets, monitoring guidelines, and outlays. It will also help finalize the implementation phases and milestones

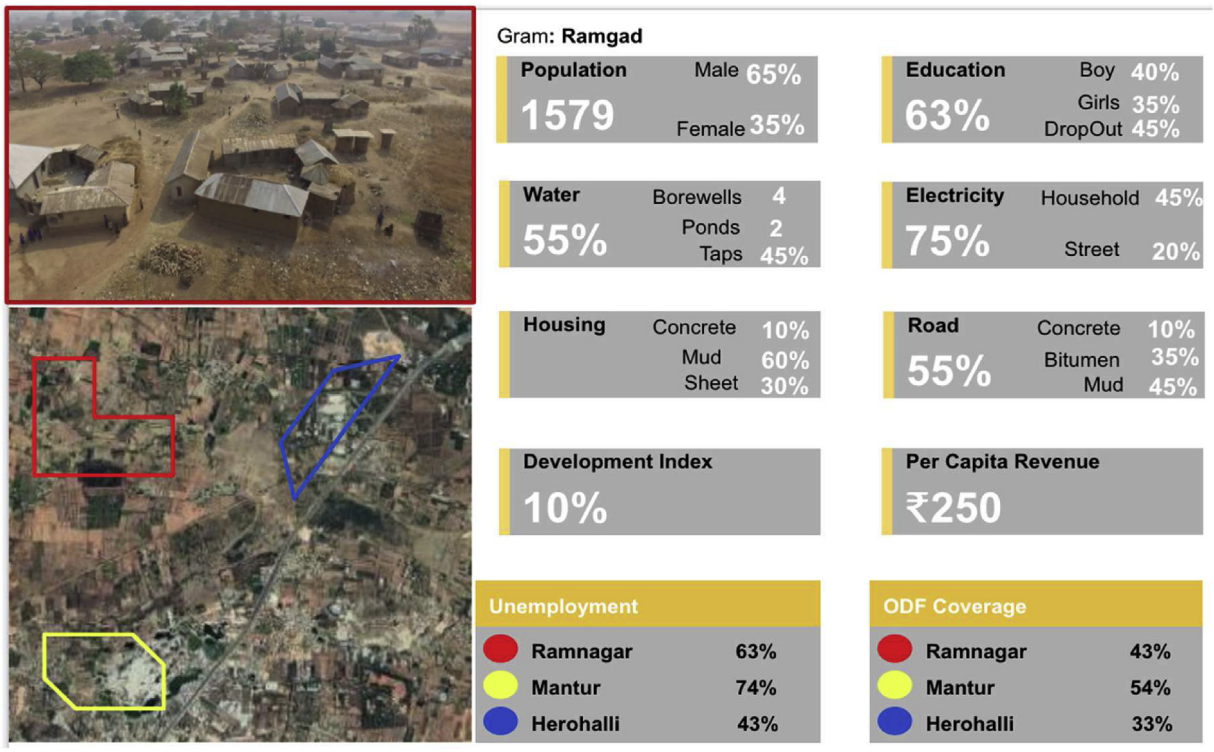

Fig. 9. Proposed dashboard (web view).

to be achieved and draw up a road map to accomplish them.

A crucial component of program execution will be to converge and integrate them with governmental schemes with similar objectives. These include housing schemes (PMAY-G), programs for rural connectivity (PMGSY), employment schemes (MNREGA, DDUGKY), and programs to improve rural quality of life (DAY-NRLM, SAGY, SPMRM, Gram Swaraj), among others. Most importantly, the recently launched web portals, e-Gram Swaraj and Swamitva Yojana, developed to accelerate the pace of development in India's villages, can immensely supplement the above recommendations. These portals provide panchayats with a single interface to complete development projects utilizing drone technology.

Crucial to the success of every plan is regular monitoring and tracking impact by collecting feedback. Real-time monitoring must be undertaken to measure actual progress achieved against a specific target set, the results of which can be shared via periodic impact reports. Real-time monitoring will also allow more proactive response when a process is found to be lacking in the desired results. Independent third parties such as local NGO representatives must undertake a quarterly or half-yearly review. An integrated approach for improving the methodology is presented in Fig. 10.

The implementation of such a plan can be supported by SPV funds and District Mineral Funds. A significant portion of the revenue being generated from the mining area must be reserved for this purpose. This is where the CSR funds earmarked for

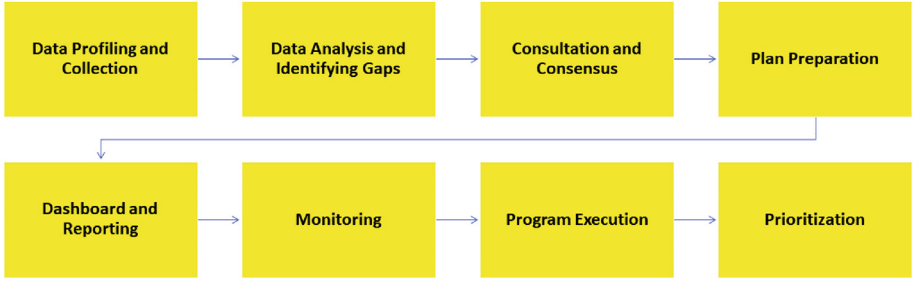

Fig. 10. Integrated approach to improve the methodology for monitoring impact.

social welfare measures by project proponents come into play. Dual-type fund allocation planning is a must; funds must be allocated under distinct categories such as education, skill development, health, among others as well as village-wise funds allocation must also be laid out. With the use of technology, we can also monitor the utilization of various allocated funds under different heads. Real-time monitoring of funds utilization will also allow for a redistribution of funds as and when required.

Real-time data on social welfare activities taken up by project proponents must also be collected. These welfare activities can be related to health, primary education, providing scholarships for higher education, ensuring delivery of public services such as water supply, contributing towards agricultural improvement, conducting vocational and skill training, promotional activities to support the self-employment of locals and assisting the local population in enrolling for and receiving benefits under government schemes. To elucidate the above using specific examples, in cases where project proponents commit to build, rebuild or repair village school buildings or healthcare centers, UAV technology can be deployed to track the progress of the same and ensure the delivery of such commitments. Similarly, building and maintenance of roads connecting villages and construction of facilities such as post offices can also be tracked. Clearly, UAV technology can have further applications beyond aerial surveying.

8. Concluding remarks

The perception of the local community regarding mining activities in their surroundings will only improve when those most vulnerable within the impact zone are empowered and enabled to build a sustainable livelihood. As mining activity progresses, mine lease owners and project leads must recognize their responsibility to lift the mine-affected households out of poverty by generating local employment. Special attention must also be paid to female empowerment in the region by facilitating the participation of women in self-help groups and federations to ensure financial inclusion in the truest sense. Needless to say, maintaining a balance between development and ecology is just as crucial.

The honorable Supreme Court of India, in its judgement, while commenting upon the impact of the mining industry, had recognized the need for "extraordinary remedy." Several mitigative measures can help the mining industry in achieving a social license to operate mines, including a detailed welfare plan for project affected persons with particulars related to funding from project proponents, support for effective rehabilitation and resettlement schemes, specific actions towards ensuring basic infrastructural amenities to the local population related to education, health care, roads, water, sanitation, among others, extended to the people without any cost or at a minimal cost. Training must also be provided to locals for skill development and employment generation. Systematic collection of data across various socio-economic indicators through dual-methodology of door-to-door social audit and real-time aerial surveys using unmanned aerial vehicle (UAV) technology can be useful in accurately assessing the socio-economic impact of mining.

While the occurrence of mineral deposits is predetermined, it is imperative that the mining activities currently being carried out have better, environmentally and socially compatible alternatives. Thus, mining, a resource extractive industry, can surely be transformed by integrating eco-friendly and sustainable approaches.

Conflict of interest

The authors declare no conflict of interest.

Ethical statement

The authors state that the research was conducted according to ethical standards. Authors have consents from the persons depicted in Fig. 4 and Fig. 5 to use their image.

Funding body

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Data availability

All data generated or analyzed during this study are included in this published article.

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