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USE OF INFORMATION COMMUNICATION TECHNOLOGY FOR BUSINESS MANAGEMENT IN MINING & MINERAL INDUSTRY

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ABSTRACT

For a business to sustain its functionalities should manage throughout the lifespan of the business. To facilitate effectiveness, the technology can assist. The mining and mineral industry regulated by Geological Survey and Mines Bureau (GSMB) is a technologically unattained industry. It is not easy to track transactions in real-time using manual bookkeeping in rural, rustic environments. Hence, the GSMB introduced the Mining & Mineral Production (mmPro) Monitoring Solution which can be operated using Web, Mobile Application and SMS. This solution keeps records, verifies and validates sand dispatch data against issued mining licenses. The pilot started by GSMB Technical Services (GSMB/TS) at 210 mining sites along two Mahaweli river banks closer to Manampitiya Bridge still run with 100% track of all transport vehicles. The officers of both GSMB and GSMB/TS now oversee the site that operates more than 400 lorries at peak. The use of mmPro has leveraged to perform better pattern analytics, such as where the dispatch loads are going, what are the most demanding days and hours of the operation. With this initiative, GSMB

has gained the viability to the royalty payment in real-time. This solution can be extended to effective queue management at the sites. With evolution, GSMB can upgrade mmPro to serve on-demand orders letting end customers to reserve and receive sand with the fullest reliability through their own transportation. Hence, deploying technologies within the mining and mineral industry increase its calibre and sustainability as an industry.

Keywords: Business Management, Information Communication Technology, Mineral & Mining Industry

INTRODUCTION

With the industrial revolution and up until now business organizations keen on generating seamless profits and cash flows. This nature of businesses continuously ensues from centuries and to foresee promising profits businesses try to formulate different strategies and academia attached to business management work on researches which introduce effective business management techniques, concepts and models over the time. Over this time, science and

technology got evolved and the technological tools, procedures facilitate every industry in every kind of economy across the world. Information Communication Technology (ICT) is such advancement in science and with ICT many industries have gained the best efficiency and effectiveness in the industries. ICT has facilitated with variety of technological implementations such as World Wide Web, Database Management Systems, mobile technologies, cloud computing and many more, which boost and manage the core-business functionalities of business entities (Karahan, 2016). Also, it should be noted that the supportive functions for businesses are managed as same as the core functionalities using the ICT.

ICT has influenced in almost every industry, including medical, education, entertainment and logistics. Moreover, ICT is now considered to be a factor which make organizations to obtain competitive edge within rivalry (Chukwunonso and Ribadu, 2011). In Sri Lankan context, many industries used and get aid of ICT effectively. The industries such as communication, tourism, entertainment and mass media effectively use ICT. Also, policy makers encourage other industries to implement ICT driven tools and techniques to progress in the business. Hence, it can be noted that in Sri Lanka there are technically unattained industries (Gunawardana, 2017).

Mining and Mineral industry is such a technically unattained industry, but the industry which drives total local construction projects. Mineral mining for the construction is very vital and mining needs to be in very sustainable manner, as this industry highly correlates and sensitive with nature. Also the mining and mineral industry functions in rurality and rustic environmental conditions where it is hard to manage ICT facilitated tools and techniques within the industry (Opensignal, 2020).

Moreover, this industry is much sensitive industry in Sri Lanka which always holds its business proceedings due to external environment and as well as being an industry which closely interrelated with natural resources, the sustainability of the both industry and the nature should be considered. So when formulating solution from ICT, it should consider all possible factors which drive the industry. This study was conducted to acknowledge the stakeholders of mining and mineral industry about the viability of implementing ICT based tools and technologies in businesses for better management in business functions. During this study the industry regulatory body, Geological Survey and Mines Bureau (GSMB) was took the initiative to implement Mining & Mineral Production (mmPro) Monitoring Solution in the sand mining sites in Sri Lanka and this solution runs over multiple platforms web, mobile, SMS. This solution records, verifies and validates sand dispatching records against the license issued by GSMB. According to the results from the solution pilot run at Manampitiya sand mining site, total business operations at the site was governed by this application with much efficiency than that of previous situations dealing manual systems of record keeping.

LITERATURE REVIEW

Ever since the industrial revolution, industries evolved with the aid through different technological eras up to digital industrial revolution. Variety of industries adopted different technological advancements in order to gain more productivity and efficiency. Followed by industrial revolution during 19th century, the evolution got hyped to industry 4.0. Industry 4.0 is encompassing more advanced ICT driven technologies for smart internal and external logistics, smart production mechanisms, smart business management and marketing and smart

business governance (Tupa and Steiner, 2019). Almost every industry has gone through or about to go for the industry 4.0. When considering the industry 4.0, businesses in different industries adopted high-end ICT aided systems and procedures for end to end business process management. Industry 4.0 encourages technologies which are into mobile computing, cloud computing and Internet of Things (IoT) along with more concepts of data mining, machine learning and artificial intelligence. E-commerce and Enterprise Resource Planning (ERP) is a novel trend in industry 4.0 (Tassel, 2020), (Jayatilake, Lanka and Withanaarachchi, 2016).

In global context every industry has influenced by industry 4.0, and when the focus drives to Sri Lankan industries, they are in verge of embracing the industry 4.0. Many industries; banking and financing, health, transportation, education, administration, manufacturing, apparel and publication have considered to revolutionized using novel technologies. The apparel industry of Sri Lanka has managed to implement the industry 4.0 aspects within the industry and apparel industry has recognized as one of the leading industries in Sri Lanka (Jayatilake, Lanka and Withanaarachchi, 2016). Furthermore, with industry 4.0 adoption Sri Lanka can gain the leverage to access global leading markets pertaining to each industry (Island, 2020).

Of all industries in Sri Lanka, mineral and mining industry is the least technologically exposed industry which has not accessed the industry 3.0. There are several reasons for the technological lagging in this industry. The main reason is that the geographical locations of mining sites being rural and rustic. According to the network coverage in Sri Lanka, the most rural areas do not have a proper connectivity for newest technologies. Hence, the technological exposure within the industry conciliations

and mining and mineral industry is lacking the technical backup to enhance its efficiency, effectiveness and sustainability. The other reason which creates resistance to the technological utilization at the industry is the reluctance towards technological tools within the direct stakeholder community. The owners show resistance solely due to the initial capital expenditure for adopting a technological solution for the business management. Usually, adopting a such tools yields many economic advantages and competitive edge to the business and hence the owners should be more aware about the business potentials in use of technological advancements (Cavalcante, 2013), (Pirzada and Ahmed, 2013).

Moreover, with this mmPro technological implementation GSMB can foresee sustainable future within mining and mineral industry. Using this technology will GSMB to eliminate illegal mining and transportation in the long run, which contrary enhances the nature and the habitats of all living organisms. Execution the mmPro will increase the transparency in governance at industry as well.

a. Environmental impact due to mineral mining

Minerals are considered to be the foundation for the human civilization. From the ancient times to the modern era, all aspects attached to civilizations evolved with the earth and earthy minerals. The high end machinery, skyscrapers and most of the technological advancements that can be witnessed during this period of time are made with the minerals being raw materials.

The minerals which need for the variety of projects are natural resources and extraction needs to be carry out. Many countries engage in mineral extraction and production while engaging in exporting as well. Minerals are in different types and categories such as native elements, oxides, hydroxides, sulfides, sulfates, carbonates,

phosphates, halides, silicates, orthosilicates, ring silicates, chain silicates, sheet silicates and framework silicates (Queensland, 2020).

When considering the contemporary context in the world, minerals are highly consumed for variety of reasons. Minerals are highly inevitable for construction, energy and metal production as well as for other industries (MineralsUK, 2020). With the exponential development in economy around world, mineral consumption also booming aggressively, meaning that the

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Whilst mineral consumption booming up due to bellicose development of different industries a major environmental concerns have emerged. With excessive natural mineral extraction red alerts are indicating, that these extractions have caused adverse environmental implications. Mining, quarrying, dredging, drilling and extracting from wells when obtaining minerals impact on both landscape and environment. Distruption of land which are suitable for agriculture, urban and recreational use, deterioration of immediate environment via noise and air borne dust, hazardous outcome for habitants within the habitats in ore creation sites are several adverse influences to the nature due to the exploitative extraction of minerals. Moreover, mining done on landscapes may distort the distribution and chemistry of surface and as well as the ground water. Also due to the acidic nature in mines, the waters origin form mines will get acidified and can cause pollution in rivers, streams and springs. Dredging for ocean minerals does not cause mechanical pollution, but results in dispersion of fine sand sediments and thereby affects on fisheries and wild life within the habitat. Even the wave currents and sedimentation patterns get distorted (Kaya, 2001), (Bauer and Shea, 2020), .

The same situation applies to Sri Lankan mining and mineral industry. Sri Lankan construction industry shows a boosting perk due to the contemporary huge constructions projects happening in Sri Lankan suburbs. The mining and mineral industry is directly attached industry to construction industry, as mining and mineral industry produces the all raw materials for the construction purposes. Mining and mineral industry predominantly consumes the natural reserves of minerals for the production of

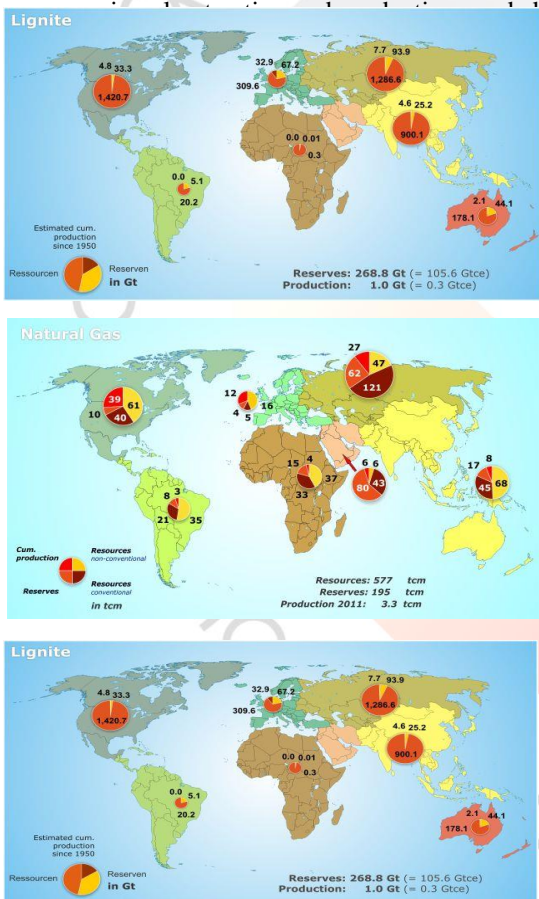


Figure 1 - Different mineral consumptions around globe by Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) in Hannover [Federal

raw material needed for construction. Due to the previously mentioned direct correlation between the construction industry and mining and mineral industry, the mineral mining increases as the construction projects get escalated. When mineral mining increases exponentially, the nature is being compromised which resulting potential ripple effects on human existence and as well as other living organisms (GWP, 2018). In the Sri Lankan context, the more tendency towards illegal extraction and mining happens with sand. Hence according to the researches due to this excessive extractions happening in Sri Lankan rivers, intrusion of sea water to inland waters, river bank collapses, riparian land losses have occurred (Piyadasa, 2009).

Considering all the driven factors within the of mining and mineral industry a proper governance was an utmost importance. Hence, the governing body for mining and mineral industry was incepted by the statutory of Sri Lanka as Geological Survey and Mines Bureau (GSMB) (Parliament, 1992). GSMB has vested with the power of exercising adequate measures to reduce and mitigate



Figure 2 - Mineral Map of Sri Lanka by www.mapsofworld.com

b. Licensing process and inefficiencies

As mentioned, mining and mineral industry directly correlates with external environment which fluctuates the stability of the industry. The stakeholders; general public, environmental activists draw the attention towards the unfavorable circumstances invoked due to illegal mineral extraction in mining and mineral industry. The riots and petitions holds the entire process in the industry, resulting the downfall in the attaching industries as well (Piyadasa, 2009), (Wickramasinghe, 2020). GSMB as the governing body had to pay more attention toward the sustainable and smooth functioning in the industry of mineral mining. As a solution GSMB introduced a licensing process for mineral mining and transportation mainly with the intention to manage the continuous raw material supply to construction industry and to ensure environment is conserved with the approach (Parliament, 2009), (Parliament, 1992).

GSMB issues 3 types of licenses under the Mines and Mineral Act No. 33 of 1992. The licenses are in types of Exploration, Mining and Trading and Transport. Exploration Licenses (EL) grant the exclusive rights to carry out mineral explorations. The Mining Licenses (ML) have three sub-categories as Artisanal, Industrial and Reserved. The Artisanal Mining License (AML) grants the authority to license-holder to mine, process and carry out trading, but all the activities pre-mentioned only can be done to the exclusively specified minerals in the license. Also AML specifies the maximum area of operations as 10 hectares and depth of 25m. Furthermore, AML has two categories as A and B based on the authorizing criteria. The Industrial Mining License (IML) provides rights to explore, mine, process and trade minerals specified in the license. IML also has three sub-

categories as A, B, and C. The Reserved Mining License (RML) allows the license holder to explore, mine, process and trade reserved minerals with the granted approval of the Minister. The Trading License (TDL) grants non-exclusive right to purchase, store, trade in and can engage in exporting minerals with a special authorization of Director. TDL also has 3 types of sub-categories as A, B, and C. Transport Licenses issued to transport mineral-bearing substances or minerals and has a specified quantity and validity duration. All EL, ML and TDL should have transport licenses to transport minerals and the bearing materials (GSMB, 2020).

Obtaining and maintaining the licensing cycle is a tedious aspect for both GSMB and the mining site owners. The processing of licenses general requires weeks and manual processing takes considerable roll out time. Moreover, even with the licenses, mining site owners try to bypass the law and process illegal raw material supplies to matchup the demand from the construction industry.

There are several reasons which cause mal-practice and exploitation in GSMB mineral licensing process. Obtaining a license for the legal mineral mining and transportation contains a tedious process with a considerable amount of lag time. This demotivates the owners at mineral mining sites as their investments in the industry is high and more time means loss of profits. Moreover, GSMB cannot track instantaneous license details from its regional offices or headquarters, as the total licensing process manually managed. These increase the license exploitations, illegal mining and ultimately nature is at a greater unfavorable state. Hence, GSMB wanted to formulate a solid and sound process for efficient monitoring and controlling in mineral and mining industry (Gamage, Weerakoon and Kokila, 2020). With that intention GSMB developed an online real-time system Mining & Mineral

Production (mmPro) Monitoring Solution to manage the licensing process and to reduce the illegal sand mining in long term. GSMB first incorporated the mmPro with sand mining sites as a pilot run.

c. Scope of Requirement for the solution

Concerning the fact that complexity and inefficiency in obtaining and maintaining licenses which permit exploring, mining, processing and transportation, GSMB initiated incorporation of software toolkits to their operations. This attempt can be considered as inauguration of stepping into industry 4.0 within the mining and mineral industry.

According to the GSMB, the solution which intended to develop should meet the objectives listed below.

1. Tracking and monitoring all types of licenses issued by GSMB should be effective and thereby, existing licenses maintenance should be productive to the organization as well as the license holders.
2. The intended system should interactive with all stakeholders attached to the mining and mineral industry in the means of real-time communications and data exchange, then thereby improve crowdsourcing for sustainable industry.
3. The retrospective benchmarking should distinguishably depict the scale of efficiencies in terms of tracking in illegal mineral explorations, mining, transportations
4. The curbing within the industry should be smooth and leveraged, so that at the end the throughput and the profits should circulate back to general public and nature.

GSMB's scope of requirement is very concerned on the above mentioned four objectives and the solution should readily provide the expected outcome with quality being the key factor. The high-level scope for the system as follows.

1. There should be access controlled user base to handle all license

related transactions within the system. The users should be clearly defined and authentication keys and related mechanisms need to be provided for better security.

2. The system which intends to develop should be able to track license oriented data such as license issued date, license type, license reference number, license real-time status, license site information, license-holder information, license capacity, license validity period.

3. After the system deployment the officers at GSMB headquarters and regional branches should be able to monitor license oriented transactions and respond interactively with general public and police inquiries.

4. Furthermore, system should be centralized and in case of network failures the transactions should be recorded in asynchronous approach and once the network is well established the data should be synched with the centralized system.

METHODOLOGY OF EXECUTION

When GSMB stepping towards achieving first glimpse of industry 4.0 the system implementations had carried out in methodical manner. Mainly due to couple of reasons such as the reluctance within the user base or stakeholders to get into the digitalization process, initial capital expenditure crisis for internet and other hardware infrastructure and furthermore the need of adequate training within the user base. Hence, GSMB and the mmPro development entities followed a strategic approach to deploy the mmPro within the mining and mineral industry by choosing the means of pilot running. The pilot run was initiated basing 3 sand mining sites and as mentioned in Sri Lanka the most prominent illegal mining happens with the sand mining.

Before the mmPro design the feasibility analysis was carried out in order to understand whether it is profitable to invest on software system. Here a benchmark analysis was carried out to understand the real sand consumption against the quantity of sand tracked at GSMB data. Then because of the drastic difference which derived from the calculation (difference between the consumption and the supply done with GSMB is the sand quantity which marketed untraceably to GSMB), it was decided to formulate efficient and effective procedures to trace how minerals are marketed within the industry.

Followed by the feasibility study, the solution was developed and the developed solution was deployed in the manner of pilot run at three sand mining sites. The sites were chosen considering the capacity of mining and transporting at every mining site island wide. The site Manampitiya is considered to be the largest and the analysis data were obtained from the site operations. The pilot run was composed of hands – on workshop of using the mobile application, limited user pilot for User Acceptance Testing, bug fix rollout and steady release.



Figure 3 Pilot run kickoff

The collected data were processed to measure how much efficiency can be achieved at the mining sites operations and as well as backend operations with the introduction of ICT tools; a mobile based

ERP platform for the sites as well as the back office operations.

Results

Initiation and incorporation of ICT tools within mining and mineral industry of Sri Lanka has shown tremendous opportunity of growth and potential to evolve the industry with industry 4.0.

The data for the analysis were accumulated from the database designated to the mmPro solution. The data have accumulated since January 2020 real time data of the pilot run. This data contains dispatch data, license data and operational data related to the mineral mining and transportation. This data also consists of crowdsourced data which aggregated through the contribution from general public and the legal authorities such as police on checking dispatch legality.

The mmPro solution tracks the license usage and license oriented information in effective and real time manner where the officers of GSMB can track the dispatches very efficiently and effectively.

Table 1 License capacity distribution

license_prefix	license_count	total_capacity
AL/B/KLT	9	250
AL/B/KU	2	50
TDL/B/KU	9	2142

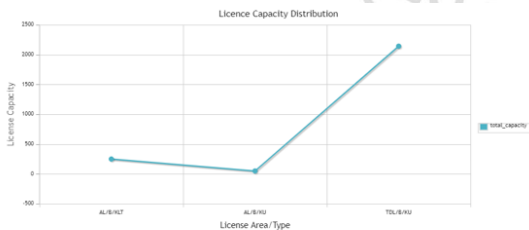


Figure 4 License Capacity Distribution

can easily generate the information regarding the license capacity distribution

where it will be advantageous to back track the illegal mining in minerals.

Table 2 Load Dispatch

license_prefix	load_count	total_cubes
AL/B/KLT	22	39.00
AL/B/KU	1	3.00
AL/B/TEST	16	48.00
IML/B/TEST	92	262.10
TDL/B/KU	57	185.00
TDL/B/TEST	30	93.75

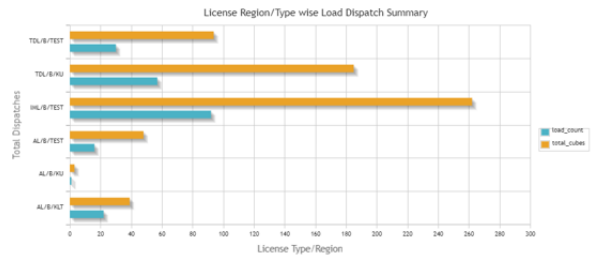


Figure 5 Load Dispatch Summary

Figure 5 show how the load dispatches distributed categorized under the different license types.

Table 3 Dispatch Load Checks

Check status	check_count	load_count	valid_count
Check	295	124	63

Through the data analysis the from mmPro accumulated data the validity of each load can be identified.

DISCUSSION & CONCLUSION

As mentioned previously, total Sri Lankan consumption for minerals, specifically sand is at higher rates that of supplied by the GSMB. The huge difference of the demand and supply in legal terms covered by the illegal mining of minerals and predominantly causes several severe impacts to the nature and the natural habitats of the organisms.

GSMB has incepted with statutory act to maintain the ecosystem attached to the mineral mining and to ensure that the industry of mineral mining evolve in sustainable manner. But with the current lethargic technologies the business operation management at mineral sites, GSMB offices are not effective and efficient, which have compromised the environmental endangers and illegal functioning within the industry.

The mmPro is modern technology facilitated application which GSMB executed to enhance their controlling and monitoring capacity within their authority of mining sites, especially to reduce illegal mining. mmPro incorporation is a striving step towards achieving industry 4.0 within the mineral and mining industry, as in the Sri Lankan context this industry is hardly exposed to the technology and its advanced tools.

Yet, during the pilot run it did notice that there are burning concerns on implementing the mmPro, such as technological barriers and getting accustomed to change within the work force. But the results proven that this approach of monitoring is viable and effective for proper business management and governance in mineral and mining industry.

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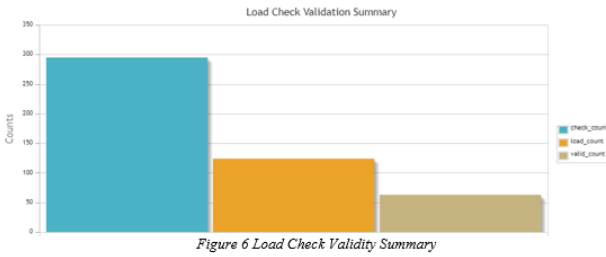


Table 4 Validity check based on users of mmPro

User Type	Check Count	Load Count	Valid Count
Admin	5	2	0
General Public	75	7	0
GSMB License Officer	4	1	0
GSMB Management	12	8	0
Lorry Driver	2	1	0
Mining License Owner	123	55	16
Police Officer	74	50	47

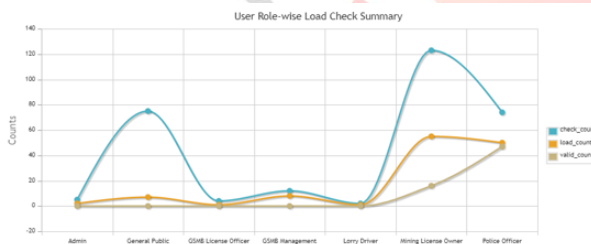


Figure 7 illustrates how the dispatches are being validated by the users attached to the application.

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