A Case Study on Problem Scenario of a Port based Merchant Pelletizing and Pig iron industry

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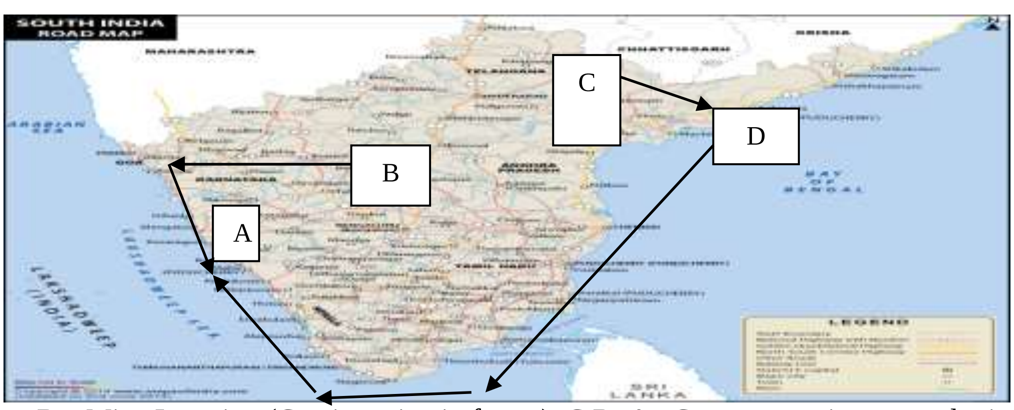
Abstract:
A scenario problem has made the top end agglomeration (pelletizing) and reduction process by blast furnace (pig iron process) unable to coexist at port location on efficiency – effectiveness imbalance. The order and disorder entropy in the system is causing port based pellet and pig iron plants as "Probability for loss making value addition plants contrast to value addition concepts. By application of Pareto principle, Peter Landsbergis formulae, effect size, there is "Conditional values at risk" due to embedded constraints in the system. The Conditional values can be used as a tool in the geometallurgical decision making process

Key words: Problem Scenario, Logistics, Ripple Effect, Order and Disorder Entropy, Conditional Values at Risk, Effect Size

1. Introduction

Iron & Steel sector and one of the major sectors for GDP growth. The iron & steel industry is a capital intensive and its sustainability highly depending not on competition alone, but 'Risks' on which the individual industry is framed. So, risks play predominant role to decide the sustainability of sector or individual enterprise. The aim of the paper is to understand the thermodynamic contractiveness of Top end Agglomeration (pelletizing) and reduction process by blast furnace (Pig iron process) when resources logistic constraints become inevitable. The flow sheet prepared based on problem scenario cannot be validated unless flow sheet proves its reliability. The low capacity utilization and idle condition of capitalized plants are the effects of problem scenario.

The Problem Scenario with the capital assets and facilities location was having a Low grade iron ore captive mine, Beneficiation plant with slurry transportation facility from mine to Port which ran for 3 decades ad ceased due to environmental issues in 2006, 3.5 MTPA capacity pellet plant operating for last three decades and 0.216 MTPA pig iron plant. Mines and beneficiation facilities were located in Western Ghats in India, which subsequently ceased and metallurgical capital assets are located at major port on the west coast of Karnataka region. To augment the present assets Outsourcing of High value iron ore, lump-fine and coke resources and secondary resources like power, water, furnace oil and bentonite. The high value resources are transported by Land and Waterway Modes of Raw Materials Transportation Facilities (LWMRMTF). The secondary resources such as lime, furnace oil and bentonite are also transported by LWMRTF. Iron ore transportation from mine to port by Railway wagons, Ship and truck transportation (iron ore mine in the state of Karnataka and Chhattisgarh. Fig 1 shows the location of the present plant and locations of out sourced resources. The product logistics was for 100 % export purpose only.

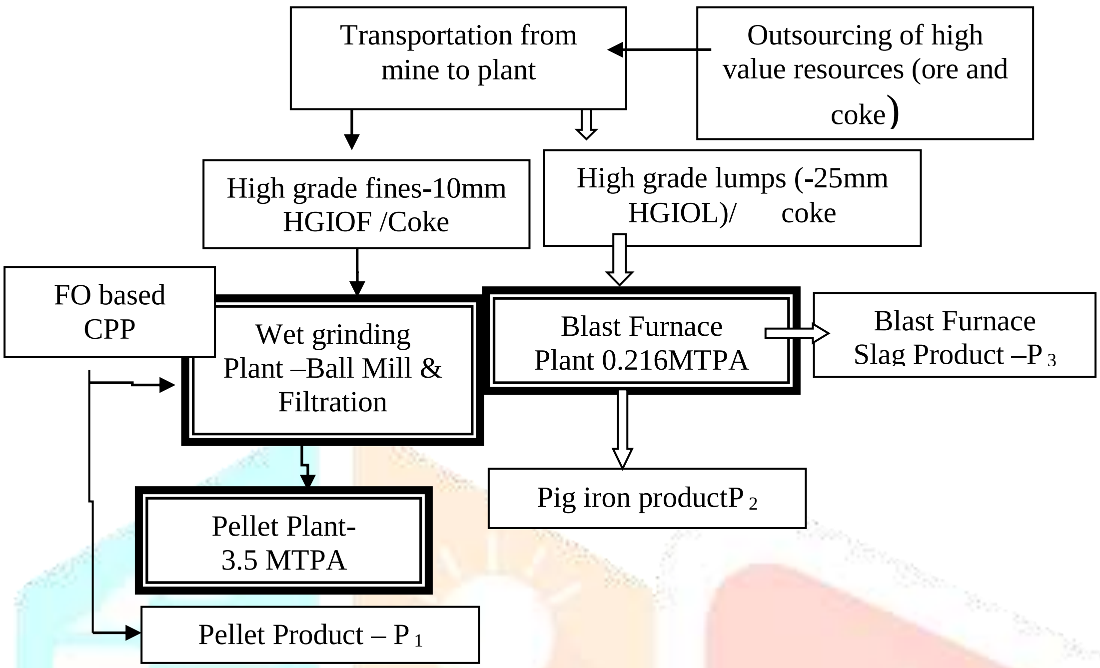


A – Port Location, B – Mine Location (Captive mine in future), C,D ,A– Current practice on ore logistics

Fig. 1; LWMRMTF of the site.

The flowseheet of Production and sale of pellets and pig iron is shown in Fig 2.

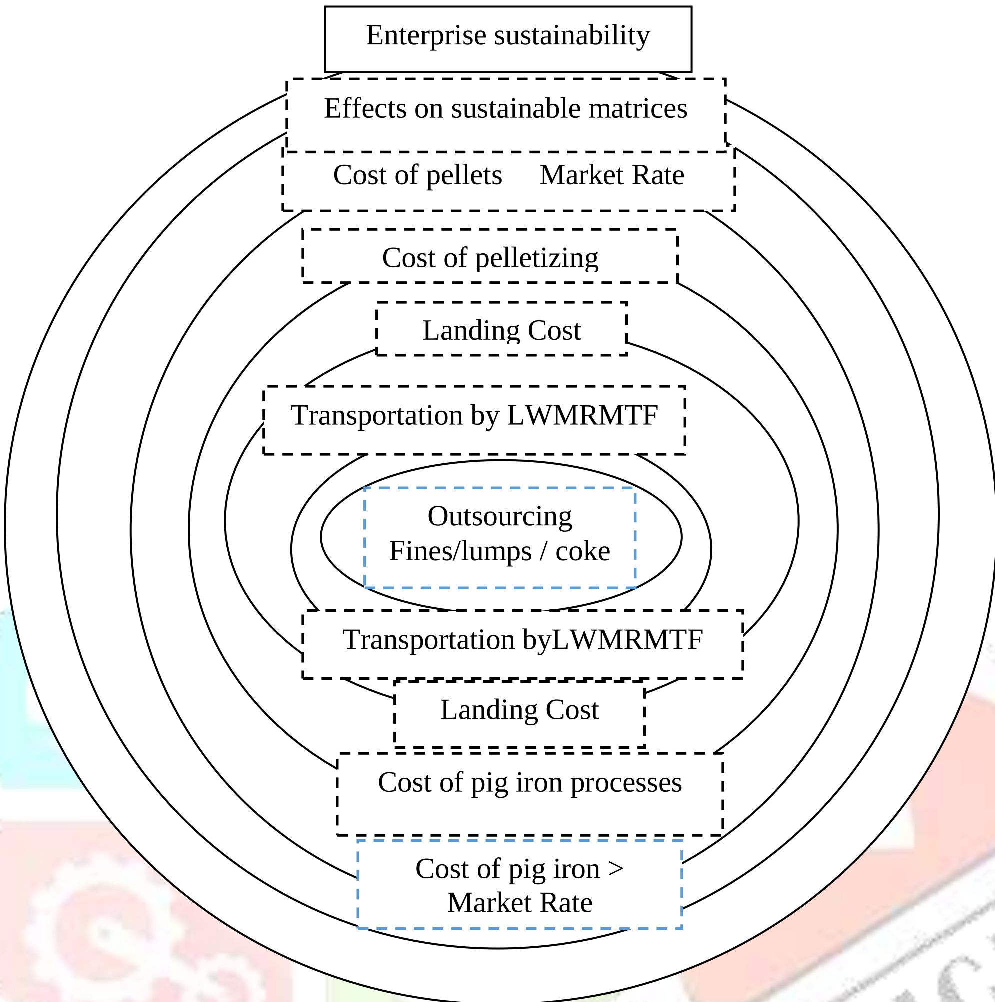
Fig.2; Flow sheet of production of pellet and pig iron at site.



2. Ripple Effect on value addition plants:

With above operating logistics, the status in the parameters are changing due to ripple effect, a situation in which, like ripples expanding across the water when an object is dropped into it, an effect from an initial state can be followed outwards incrementally(Wikipedia,Ripple effect (2018)). (Refer Fig 3.)

Fig. 3. Ripple effect on value addition products.



2.1 Effect of Ripple Effect on Status of Rationality Function or Constraint Function:

The rationality of market rate to product cost value function or constraint function becomes as shown here instead of "lesser than" one

$$\text{Efficiency – Effectiveness or Constraint function} = \frac{\text{Market Rate (MR1)}}{\text{Cost value of products } (P_{CV})} \geq 1$$

The probability of loss making is high for pig iron making and pellet making in decreasing order leading to low capacity utilization since 2006.The cost value of the product is incrementally expanded as like ripple effect and the expansion depends three dimensional property of quantity, quality and operating logistics of capital assets

2.2 Theoretical Frameworks:

As per strategic business expansion planning, pellet and pig iron plant came to existence toper flexible long-term plans. Loss of iron ore captive mine and slurry transportation facilities led to problem scenario. This has led to resource logistics. The iron ore is outsourced from the mineral rich states of India due to non-availability iron ore captive mine. The coke is also outsourced from China due to quality and availability. In the absence of coke oven plant, purchasing of coke becomes inevitable operating logistics. The transportation logistics and permit for import or local purchase of primary and secondary resources decide the landing costs. The landing costs and the cost of value addition processes decide the cost value of product. The metallurgical flowsheet is parallel short path flow for pelletizing and pig iron process separately (Ref Fig 2).The problem scenario and logistics of the system have made the flow sheet unsuitable at port location due to Outsourcing and Land and water ways modes of raw material transportation facilities

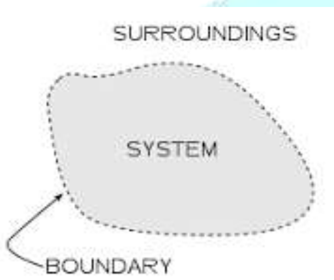
(LWMRMTF).The problem scenario changed the flow sheet to current practice and logistics are management principles to achieve mission focus.

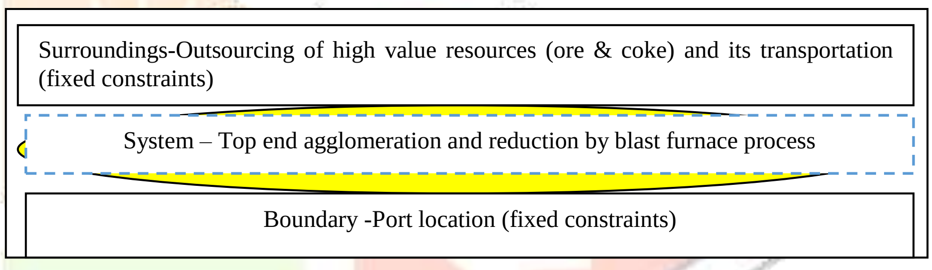
3 Diagnosing the Problem by Entropy of the system

The logistics of resources and metallurgical processes unable to coexist at port location as the efficiency-effectiveness condition could not be fulfilled. The inputs costs and products value differs as per the given logistics.

Refer the entropy diagram which is a self-explanatory for Location – Allocation – Logistics Matrix (LALM). The total entropy of the universe can never decrease. Entropy can decrease somewhere, provided it increases somewhere else by at least as much. The entropy of the system is defined as the logistics of resources and the top end agglomeration (pelletizing) and reduction by blast furnace (pig iron process) representing the system's thermal energy for conversion of Less value - demand product" is the prime cause for entropy imbalance. Such imbalance is interpreted as the degree of disorder or randomness in the system Therefore the "Thermodynamic entropy is an extensive property, meaning that it scales with the size (flow sheet distance) or extent of a system (top end agglomeration and reduction by blast furnace).The entropy of mineral processing & metallurgy decreases when it interacts with some other system that is the resources logistics such as"outsourcing of high The logistics of resources and intermediate value addition processes become entropy imbalance when value addition facilities are located at port or gravity location. The data is shown in Fig 4. The assets designed for captive mine resources with slurry transportation facilities becomes ineffectiveness when there is no captive mine and slurry transportation facilities.The logistics have gradually declining the capital assets into disorder as "Lack of order or predictability"

Fig.4; Entropy of the system





3,1 Contrast of Organic value addition process:

Top end agglomeration (pelletizing) and reduction by blast furnace (pig iron) are organic value addition processes.

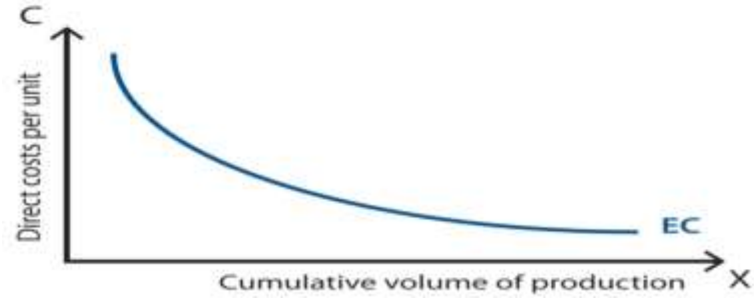
Among agglomeration, pelletizing is considered as top end as this process involves more steps than other three agglomeration methods such as sintering, briquetting and nodalizing.However the economics of pelletizing will be higher. Both these processes are not fully technological dependent value addition methods as the characterization of blast furnace does not permit to use 100% pellets as feed burden.The versatility of blast furnace is to convert iron ore into molten state by removing oxide mineral and use this hot metal for pig iron making or steel making through converter process. Limiting of hot metal to make pig iron bringseconomic loss due to the cost of reactant mineral (coke). It means the versatile of blast furnace should not be limited to iron making.One of the major concerns is the cost of coal/coke and its availability in India. The coal is available only in few northern states like Bihar and west Bengal and hauling for long distance involves higher cost due to bulk density when compare with iron ore apart from ecological and environmental problems. The landing cost of iron ore and coke differs considerably. But the quantum of iron ore and coke requirements depending on design capacity of flow sheet and generally high for iron ore.

The combinations of pelletizing and pig iron processes are contradicting in terms quantity and cost. Higher the capacity higher is the operational expenses.

3,2 Experience curve and its Contrast:

The port based merchant pelletizing and pig iron processes will undergo higher expenses for increased quantity against the experience curve as shown here. It is because the logistics path flow.The higher the cumulative volume of production (X), the lower the direct cost per new unit produced (C). Therefore, the experience curve will be convex and have a downward slope, as shown Fig 5.(Economist 2018)

Fig 5 Experience curve.



In the case of capitalized value addition methods i.e pelletizing and pig iron with embedded constraints, the cost per ton will increase due to entropy imbalance which cannot be seen and only realized as shown in Fig.6. As per LALM, the facility location (port) triangle inequality condition is violated by the system. Of the three variables such as: Resources, transportation and transformation processes, the resource's value is higher than other two.

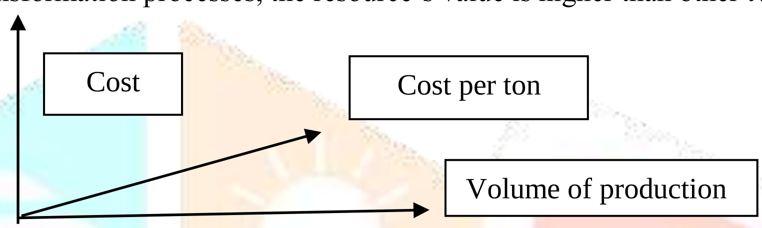


Fig.6; Linear increase of cost/ton with production volume

4. Economic Tool to measure Order and Disorder Entropy

The entropy of the system can be measured by order and Disorder entropy method.Entropy has often been loosely associated with the amount of order or disorder in a thermodynamic system. One of the simpler entropy order/disorder formulas is that derived in 1984 by thermodynamic physicist Peter (1984), based on a combination of thermodynamics and information theory. Peter(op,cit) opines that when constraints operate on a system, such that it is prevented from entering one or more of its possible or permitted states, as contrasted with its forbidden states, the measure of the total amount of "disorder" in the system is given by:

$$\text{Disorder} = \frac{C_D}{C_I} \quad \text{and} \quad \text{Order} = 1 - \frac{C_O}{C_I}$$

C_D is the "disorder" capacity of the system, C_I is the "information" capacity of the system, C_O is the "order" capacity of the system.

4.1 Comparison of order and Disorder Entropy to Sustainable and Risk:

The capital assets and resource's logistics act as constraints and the thermodynamic properties of the system unable to utilize to maximum. Underutilization of thermal property leads to "order and disorder" and the same is equated to geometallugy as: C_D – Disorder = Risks in LALM, C_I – Information capacity (Discussed in a separate paper as it is the main contend for research) C_O – Order = Sustainable of LALM.

Order = Sustainable = 1 – Risks = 1;Disorder = Risks / sustainable = 1

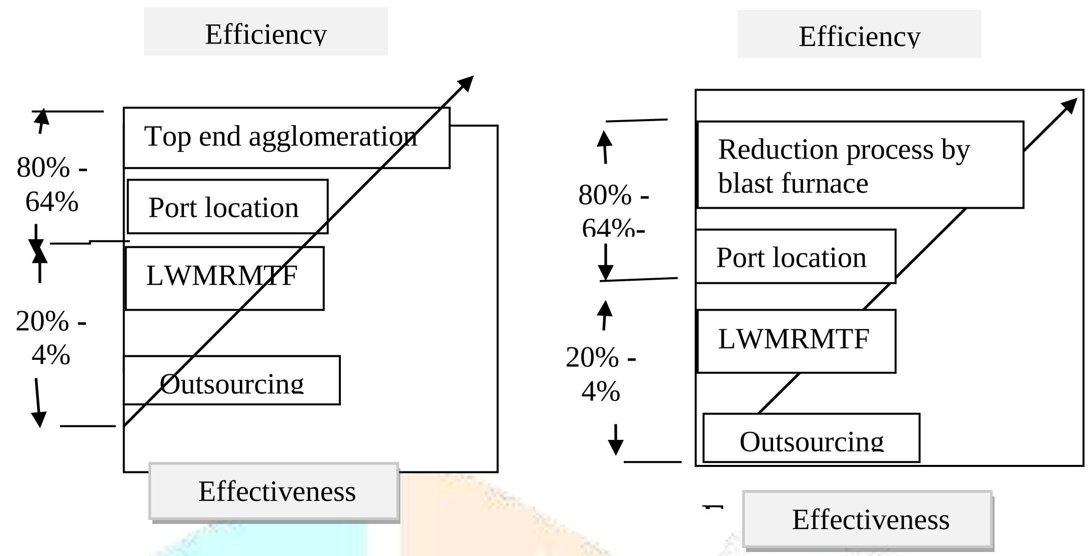
Therefore the entropy of the isolated system (LALM) can be expressed as:Entropy (S) = Order + Disorder = or > 1

4,2 Empirical Tools:

The empirical tools are: Pareto 80 /20 rule (Cause and Effect measurement), Pareto 64 /4 rule (Impact Measurement).Empirical Tools to measure cause and effect by Pareto 80 /20 rule shown in Fig. 7.

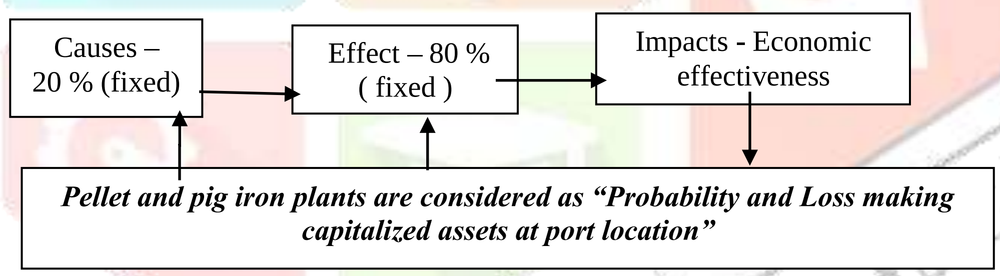
The Pareto Principle or Pareto 80/20 rule is used for cause and effects comparison between resources and value addition processes or Transformation processes.The Pareto(2018) principle (also known as the 80/20 rule, the law of the vital few, or the principle of factor sparsity) states that, for many events, roughly 80% of the effects come from 20% of the causes.20% of the causes (outsourcing and its transportation) are responsible for 80% of effects on pellet and pig iron plants separately and also to the enterprise.

Fig. 7.:Effeciency and effectiveness graphs



Therefore, the cause and effect is the natural or worldly agency or efficacy that connects one process (the cause) with another process or state (the effect), where the first is partly responsible for the second, and the second is partly dependent on the first. Due to parallel short paths the flow sheet distance is doubled shown in Efficiency – Effectiveness graph. The effect of 80/20 Parato principle in LWMRMTF is shown in Fig.8.

Fig. 8;The effect of 80/20 Parato principle in LWMRMTF



4.3 Empirical Tool to measure Impact Sizeby Pareto 64/4 rule:

Pareto 64 /4 rule is used to measure impact size. The impact size is "Conditional Values at Risk" (CVaR) (Annon 2018).The operational efficient pelletizing and pig iron processes are unable to be effective at port location due to entropy disorder. Since port location is fixed constraint, the capitalized assets i.e pellet and pig iron plant have to face uncertainty. The uncertainties of capitalized assets are classified as investment risk as per literatures and expressed as: Expected shortfall is also called Conditional Value at Risk (CVaR), Average Value at Risk (AVaR), and expected tail loss (ETL). ES estimates the risk of an investment in a conservative way, focusing on the less profitable outcomes.In the literatures, there are many procedures highlighted for impact assessment. But in the current case study, the assessment to be done for capitalized value addition processes, its plants and the enterprise. So, it is opted to assess the impact assessment as per Pareto 64 /4 rule. Table 1 shows the effect of Parato80/20 rule on Conditional value at Risk.The impacts are calculated as:80 % of 80 = 64 %; 20% of 20 = 4%Consider 64 % as sustainable level and4% in eco efficiency of the system. The Efficiency – Effectiveness (EE) of LALM are Eco efficiency (η_{eco}) and Condition for Eco efficiency < 1 or > 1

$$\text{Eco Efficiency } (\eta_{eco}) = \frac{\text{Economic Realization (cost values)}}{\text{Environmental inputs (Cost values)}} = <1 \text{ or } > 1$$

The greater or less than status is depending on cost value of denominator and numerator

P_{CV} = Input values + Output values ;$P_{CV} > MR_1$ = Low eco efficiency = > 1 = Stability factor

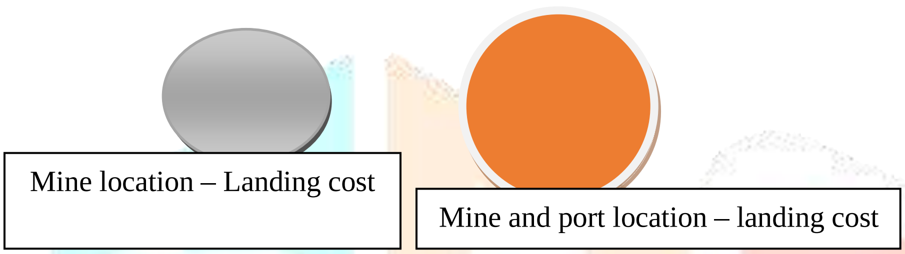
$P_{CV} < MR_1$ = High eco efficiency = < 1 = stability factor.

Table 1; Effect and Impact size the effect of Parato80/20 rule on Conditional value at Risk

Sl.No	Impact on functions	Mine & port Location
1	Status in the Constraint function	$\mathbf{P_{1..(CV)}}$ **> or <** $\mathbf{MR_1}$and $\mathbf{P_{1..(CV)}}$ **>** $\mathbf{MR_1}$and
2	Entropy Status of capital assets	**Probability and loss making**
3	Sustainable level	**64 %**
4	Risk Level	**36 % + 36%**
5	Drop in Eco efficiency	**4 % + 4%**

The reductions in eco efficiency level and consequently to sustainable level are attributable to entropy disorder at mine& port location.Though the similar operations are doing at mine and mine and port location, the landing costs for mine & port location will be higher due to resources logistics and "Load – Distance (LD) factor (Fig.9)

Fig.9 Load and Distance factor.



4.4 Empirical Tool for Evaluation of Effect size:

The causes, effects and impacts are likely to be same for mine operations as well as mine & port operations. However the effect size are different for the same value addition processes. Effect size is a simple way of quantifying the difference between two groups that has many advantages over the use of tests of statistical significance alone. Effect size emphasizes the size of the difference rather than confounding this with sample size.(Table 2)

Table2 Comparison of effect size

Sl.No	Impact on functions	MineLocation	Mine & port Location
1	Status in the Constraint function	$P_{1,2..(CV)} < MR_1$	$P_{1,2..(CV)}$ > or < MR_1 – Pelletizing and Loss for pig iron process
2	Entropy Status of capital assets	Acts as value addition assets	Probability and loss making assets
3	Sustainable level	< 100 %	64 %
4	Risk Level	N/A	36 % + 36%
5	Drop in Eco efficiency	N /A	4 % + 4%

5. Results and Discussion:

Since LWMRMTF is indispensable operating methods, whatever costs incurred do not add any value to the process except increasing the cost of operation. The cost escalation needs to be included as the cost of the products.

The operational efficiency of the pellet and pig iron plants are equally mine based operations. But the economic ineffectiveness is due to associated logistics which act as constraints.

To measure Order and Disorder Entropy, three variables'value is required. Lack of procedure or methodology has made the formulae less familiar since it appeared in the literatures. In this paper these three variables are correlated as C_D is the "disorder" capacity of the system = Risks in the system, C_I is the "information" capacity of the system = Link formulae between risk and sustainable, C_O is the "order" capacity of the system. = Sustainable level of the system.Information capacity is defined as "it is a measure of its "goodness." The actual amount of information depends on how information is represented

Since entropy is a thermodynamic property, it varies as per size. In geometallurgy, the size is determined by the flow sheet length comprising three dimensional property of resources, value addition methods and products. The shortest path requires high value resources.

6 Conclusion

In geoemtallurgy, location plays predominant role to decide viability. The selection of location is not only for client's proximity but also for optimality under certain characterizations. When there is a change in the operating characterizations at later stages due to problem scenario, the selected location and capitalized assets become liability and uncertainty due to ripple effects. The uncertainty is mainly due to entropy disorder between logistics under the problem scenario. The application of Pareto principle and effect size concepts are revealed that there is a conditional values at risk. The order and disorder entropy of Peter Landsbergis is equated to geometallurgy parameters in the form of eco efficiency. The problem scenario has tagged the capital assets as scenario constrained pellet and pig iron value addition plants and conditional values can be used as tool for decision making process.

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