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Spatial Modeling for Location Optimization of The Nickel Smelter Project to Improve Estimated Accuracy of Investment And Operational Maintenance Costs.

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***Abstract*—Investments in the mining industry have recently increased with substantial funding for every project such as the construction of a smelter plant or a refinery in the downstream nickel mining process business. The accuracy of cost estimation is very important in business and project planning, especially in investment in the mining industry. Projects with a large investment scale such as smelter construction or refineries are prone to common problems such as a decrease in investment value due to the low return on investment that is less promising. This can be realized with knowledge of the project location which forms the basis for cost estimation. The location factor is usually used to adjust the estimated cost estimates based on the project location, where the cost estimate can be improved by using several methods, namely spatial models for location optimization. Location is very influential in every construction work, especially the preparation and planning stages in the entire business process such as the nickel mining industry. One of the features of this approach is the spatial model for location optimization and project work indicators by considering the business location of the nickel mining industry with smelter or refining projects. The main objective of this research is to improve the accuracy of the estimated investment and maintenance costs by using a spatial model that can optimize the project location factors. The spatial method in selecting project locations can be a practical and effective solution to the problem of increasing operational and maintenance investment in the mining sector downstream program with a focus on IRR analysis and an alternative estimate model that can be generated from the results of the spatial model.**

Keywords— Location, Cost Estimates, Investment, Operations and Maintenance, Spatial Model

I. INTRODUCTION

Investments in the industrial mining of late have increased the funding which is quite large in each project such as the construction of the plant smelter or purification. The accuracy of cost estimation is very important for the initiation of industrial business development, especially in investment in the mining industry. Policy of the government of value -added, which is one of the core requires companies mine for processing the results of mining in the country, still continued. Value added in the industrial mining of nickel in particular in the form of a smelter or mill purification which has a value of an investment that is quite large in value. The construction project itself could not be separated from the four factors: cost, time, quality, and safety. Therefore, any implementation of a construction project requires a good project management, which aims to avoid or minimize any risk projects that may occur include the risk of cost overruns, the delay time of the execution, as well as less accurate estimate of the cost of the investment project. A project will be successful if it is in accordance with the planned cost or budget, on time, and according to specifications. Thus, a high level of expertise, knowledge and experience is needed in estimating project costs to managing project cash flows during the implementation stage, expertise in coordinating project resources, and good project control so that cost overrun can be avoided. Every construction project implementation, wants to be successful in the implementation of project completion in a timely manner. To meet these objectives three targets must be met, namely the amount of cost or budget allocated, and the time and quality that must be met. These three things are important parameters that support the smooth implementation of the project.

Making plans for a construction project always refers to the estimates or estimates that existed at the time the development plan was made, therefore problems can arise if there is a mismatch between the plans that have been made and the actual reality. So the impact of what often happens is the delay time of execution of the project may also be accompanied by the rising costs of the project which is based by not accurately estimate the cost of which is generated. Delays occur in almost every project work and have different problems. Some projects were only a few days later than scheduled, however, some construction projects experienced delays of up to several years. It is very important to know the causes of project delays in order to minimize and prevent project delays. Factors which became the cause of the delay in the project is inaccurate estimate of the project. Basics of financial projects is the estimated cost of which includes the calculation of costs for labor, material, equipment overhead and profiles. Barriers that can occur in the project cost estimation process are : incomplete drawings, construction data, and estimator experience [12]. Inaccuracy of estimation this would lead to the occurrence of swelling costs. For example the price of purchase of materials or lease equipment that is more expensive than that planned and locations are not predictable with good.

The accuracy of the estimated cost at project in general very be linkage with the plan of development of business value -added, which is a matter fundamental to the success of the project construction is estimated the cost of beginning the phase of planning. Estimated cost is developed by regularly throughout the cycle of life projects. In the initial stages, such as planning and conceptual design, forecasting helps the owner determine the general financial viability for budgeting and programming purposes and forms the basis for project scoping. Construction is also an industry -based project, and estimate the cost to do at a time that is different from the cycle of life project to predict the results of its economy. All cost estimates can be classified into the two categories of main that is conceptual and estimate costs detailed. Conceptual cost estimation, which is the basis of successive cost estimates, is used for programming and budgeting and is based on a small design. Approximate cost of detailed use to offer and is based on a design that is almost finished. In the project that became a study case is the value of investment of the initial US $ 684 million, of course, will affect the performance of the project with the magnitude of the value of investments such. In the project is the owner of the business experienced a problem major that delays in the project due to inaccuracies in the phase of planning and high mislocation as well as the factors external such as the licensing of land that a high level of uncertainty in the case of such.

The accuracy of the estimate of the cost is very important to the success of the project construction where angle of view of the owner, inaccuracies will be presented in two forms that is harmful, disparaging and estimate too high. When slighted, a project will be to force an owner to obtain financing additional, to reduce the space the scope of the project, or, even, for the termination of the relationship working. Owners often incorporate possibilities in in their estimates of the conceptual to mitigate the consequences of potential understatement. Conversely, projects that are too high restrict the number of opportunities of business that can be pursued by the owner at the time specified. Improving the accuracy of estimates of costs is the key to overcome the shortage of methods of estimation of the cost of the time of this. The accuracy of cost estimation is limited by three factors [17]. First, in the initial design budgeting phase, the fully developed project scope was not available. Secondly, most large owner does not have the project period and were enough to develop a database of costs internally [1]. Various stages of the project in which the estimate of the cost of production, identified five grade estimation of the cost in the whole class cycle of life projects using the definition of space scope of the project as the most factor significant to classify each grade estimation of costs in conjunction with the use of end and the range of accuracy that is expected. Accuracy is lower estimate of initial most large caused by the space scope of the project are not specified, which is not to be avoided because the owner usually only have a rough understanding of the space scope of the project at the level of conceptual and understanding is growing in the whole design. Asymmetry of information specifically when it affects the amount of inaccuracies early because the estimators are not able to be accurately take into account the changes and the risks consequent on an idea that has not been fully formulated. The accuracy of estimates is also restricted by the method of adjustment that is used to develop the estimates. Although there are some adjustments were taken into account in the estimated cost of the conceptual which are time, location, size, and complexity [17], the features of the approach to this is the optimization of locations and indicators of performance in the work of preparation, and the stage of licensing as well as the stage of planning. The aim main of research this is to analyze model of spatial optimization of locations in order to improve the investment and operation maintenance and also identification accuracy of the model of spatial optimization of locations that improve investment and operation maintenance. It was able to be realized with knowledge of the location of the project that became the basis for the estimation of costs. The location factor is usually used to adjust the estimated construction costs based on the project location, where the percentage of the estimated cost can be increased by using several methods, spatial models and site optimization. This method brings new things to understanding a situation where investment and maintenance operations can be viewed from a geographic location by looking at factors taking into account the overall nickel mining business process.

II. Related Work

This section discusses the related work spatial model for location optimization of nickel smelter project to increase estimated accuracy of investment and operational maintenance cost.

Smelter project that will focus on this research is HPAL methods. HPAL is used as the hydrometallurgical leading the industry for the extraction of nickel and cobalt from ore limonite, which extracts over many nickel from Aluminum. Although both heaps and leaching acidic atmosphere agitative process offers several advantages over capital is low cost, equipment process more simple, the period of increase in the rapid and maintenance much easier with the availability of on-stream high. HPAL also has some weaknesses which most advantage is important that offered HPAL on AL is in under the condition of the reaction temperature is high most of large iron and aluminum are leached deposited back almost all acids are consumed in laundering. The result is a significant consumption of acid which is lower. Often desirable to follow a strategy that is different to process lateritic of the type that is different, especially the hematite, goethite and saprolite in nature. This includes milling the ore refined, the reaction controlled redox, the addition of salt, the use of temperature and pressure were much higher, sulfation ore laterite to improve the ability of leaching and roasting as the step of pre-treatment prior to leaching acid [31]. HPAL may also involve developing a process hybrid followed by a stirred tank wash. HPAL process require ore that most large are limonitic, in the case of laterite dried they contain nontronite and or smectite. In general, HPAL process used when the ore contains saprolite, and has a Mg is low, usually limited to be less than 4%. If the content of Mg is high is present, then the consumption of acid will be higher. The aluminum ore content should also be low. In the process the ore is ground and mixed with water to produce 20–30% solids slurry. The solid content is increased to about 45% using a thickener [31].

Nickel and cobalt precipitated from solution together as a hydroxide mixture, using magnesia. The remaining nickel and cobalt are treated using lime with manganese eliminated in the final precipitation step [3]. That precipitated hydroxide mixture further purified by leaching both metals into solution

of ammonia, ammonium carbonate, followed by the extraction solvent, which oxidizes the complex amine cobaltous be cobaltic are privileged to extract nickel into a phase of organic liquid. Cobalt then precipitated by Nash and nickel powered electricity [43]. Beside formation of crust in the autoclave during the washing and the elimination of her, the cost of the environment which is high due to the consumption of acid is also an aspect of the negative of the HPAL [34]. The author reviews the HPAL process to be used as a case study for a nickel smelter project, which is based on the HPAL (High Pressure Acid Leaching) method. HPAL Smelter Plant is a plant needed to carry out the HPAL) process in nickel refining [27].

The process of business as a set of activities structured which is designed to produce output specific [41]. While y ang other offers variants, but the thread of red is that the business is a collection of various tasks that generate output. The implementation of the process of business generics are used by companies and consultants leads to the conclusion that the level of abstract some consensus can be achieved through a series of processes of business public [11]. The structure of the chain value of industrial nickel- divided into the following this group: Chain industry upstream, i.e., chain of mining and products of mining are forms of ore of nickel. This nickel ore is used as a raw material in processing and refining processes [15]. Processing and product distillation could be NPI, nickel and matt nickel, depending on the technology that is used. Then, the products are, the NPI, nickel and matt nickel, are processed much further into intermediary products downstream in the form of a battery, Ni alloys, plating Ni, and various products of steel resistant rust. This product will serve as the raw material for each downstream industry. Eventually, they will do so with distributed to the end of them in the form of equipment home household, ships, construction, agriculture, chassis electronics, defense, oil and transportation of gas, the vehicle, and a train fire [15].

Upstream industry includes the activities of a manufacturing company with the distribution (which can manufacture, assembler, or Both of) and their connection to the dealer they (dealers second tier) [41]. The supplier relationship can be extended to several strata, all the way from the origin of the material (e.g. ore, plant growth). Downstream is often called down streaming or value adding, which means that efforts to dampen the export of materials raw and otherwise encourage the industry domestic to use materials such as increasing the value -added domestic (while creating a field of work) [37]. If it is to be exported, then that is exported is the stuff so, the results of the processed material raw it. Export lipstick or chemical blends, not palm oil. network of production regionally and globally, downstream is the process of policy by relocating the source power to the advantage of comparative countries concerned [45].

Project planning is an owner-driven planning process to gather sufficient information about potential risk versus likelihood of success, so that the owner can decide whether a project should be continued or canceled. Spatial systems were also developed to estimate construction costs, land acquisition costs, and operation and maintenance costs for road construction projects during the feasibility study using geographic information systems (GIS) and BIM [36]. Spatial is also used to consider the spatial aspects of contractor screening to determine their competence in completing construction work at a particular location [24]. Government regulatory requirements have had a sizeable effect on the PCP stage. Construction plans must comply with government laws and regulations. spatial aid planners in environmental impact assessment and evaluation while obtaining the necessary permits from the government. This requires multiple levels of information (e.g., transport networks, political boundaries, water and wastewater networks, soil types, vegetation) to produce feasibility reports and recommendations. The use of multiple spatial layers helps in fulfilling planning requirements such as the PCP stage. A pre-construction survey is a topographical survey that studies natural topography and finds the location of all utilities above and below ground that will be affected by construction activities. This involves a survey of filling materials, aggregate sourcing, transportation costs, viable routes, horizontal and vertical alignments, and evaluation of route alternatives to select the best. spatial planning facilitates the analysis of the topography of the site which usually governs the choice of construction method. Extending utility to the site: Topography plays a major role in extending utilities such as water, electricity and gas to the construction site. Demonstrates the use of spatial automation in the tedious route planning task of large vehicles in a construction site [10]. Surface and subsurface conditions: Surface and subsurface conditions at a site influence the method and choice of equipment construction, which, in turn, affects project costs and implementation [1]. Developed a database for storing soil data obtained from a series of boreholes that were found useful in basic analysis, design, and planning [35]. Use of total spatial also can be applied to develop subsurface 3D profile of the borehole data [8].

Construction scheduling: Scheduling leads to all other functional plans in terms of time invested, followed by layout and logistics in the PCP stage [28]. Spatially integrates the 4D modeling of the construction process with its environment [6]. Spatial development can be used to simulate construction operations in a 3D spatial environment to plan and detect logical errors in the schedule [30], and can develop a spatial - based scheduling model to optimize infrastructure maintenance programs involving multiple distributed sites. [19]. Planning is an important function of project management. However, it appears that medium and small contractors do not see it as a priority and end up doing jobs where there is little planning [14]. If planning is carried out from the tender or bidding stage it will help in reducing costs, allowing for realistic schedules and labor productivity. Limited guidance for contractors is available on effective planning because planning is considered a macro-level function for the owner. The detailed micro-level planning process for contractors is described below. It is important to start planning by assessing the contract risks and developing an initial summary plan. The next step is to develop a site layout plan and identify a sequence of works to further develop the operational program. The design and construction strategies need to be reconciled and if necessary, the initial plans should be revised and communicated to all and ultimately enforced the final program. The importance of pre-project planning and its influence on project success has been recognized even though the process differs from that of the pre-project organization planning process varies widely across

the construction industry from one organization to another, and from one business sector to another [9].

Spatial use in the development of an optimal land displacement planning system takes into account variations in soil type, and the presence of transverse barriers such as rivers and valleys throughout the project [18]. Spatial use for planning and monitoring of iterative constructions. Planning for safety and low disturbance: spatially facilitates the development of a safe execution sequence at the PCP stage [6]. Spatial can also develop tools for safety monitoring in hydropower station construction [25], and can develop web-based spatial decision support systems for proactive health and safety management for linear construction projects [5]. Open source software is a free program created through the collaborative efforts of programmers from around the world. On-site planning can be solved especially the problem of spacetime conflicts where spatial facilitates in modeling when, where, and how long space is needed in the work site [6].

Aspects of geography studied the relationship causal symptoms on the surface of the earth, both in physical as well as concerning the creatures living along with the problem through the approach of spatial (spatial approach), approach to ecology (ecological approach), and the approach to regional (region complex approach), for the benefit of programs, processes, and development success [7]. There is a danger that standard functions in spatial ownership are used, for example, in the interpolation or estimation of distance functions not recognizing the need to calculate the distances of a large circle. The spatial pattern of the phenomena of their interaction within a given region and in relation to the rest of the world. Factors of geography is a subject that is more extensive that crosses many boundaries of formal knowledge, linking the findings in geology, climatology, agriculture, technology, and economics with several disciplines of science cognate [46]. Nature of modeling and search patterns of spatial is that the concept also must contain some components of the projection. Patterns come and go according to how we project data. Components of the second of a pattern is that given by the process that produced it. The process of a kind that can be highly deterministic, with the result unique in each location. The temptation to think that this must result in a pattern that always appears simple must be resisted. Now there is literature substantial that use cellular automata models to show how the rules simpler than the behavior of the spatial, combined with the approach of the system dynamic discrete, can produce a pattern that is very complex. Approach introduced to geography [13]. However, more common to regard the process of spatial as stochastic result in any location or area representing the election probabilistic (random) from several distribution plants that underlie [29].

In economic region, the theory of location has shifted its attention from the hard factors (costs), associated with the proximity of markets and suppliers, to the relative Factors, the level of knowledge and quality of the environment. In writing this we focus on the quality of spatial as factors that may influence the selection of the location of the company and its implication to the layout space strategy and policy. Selection of locations tend to be more relevant to the development of economic cities and regions rather than a few choice others who created the organization. The level of employment, the level of income of the region and the growth of most large depends on the location and selection of investments were made by a number of organizations [32]. The optimal location for an organization can easily be calculated using a variable that is mentioned. The assumption is important in terms of this theory is that the organization acted as rational in the market competition that is homogeneous and that employers receive information complete. Differences regionally in the cost of labor employment decreased as a consequence of the increased mobility of labor work [38]. At the end of the century, both twenty, there are against shifting tendency location. The choice of location was no longer centered on pure facts. Personal perceptions by entrepreneurs about the business environment play an important role, as well as the possibility to participate in various economic and social networks. Body of thought behavior and institutions in accordance with good insight that changed this in the decision location [32].

Optimization location is a problem common and often complex in business and engineering. The complexity of the location problem is due to the nature of the problem and its decision criteria which, depending on the area of application, the facility location model takes a variety of factors into account. For example, a logistics model usually involves route planning factors, land costs, and logistics performance [22]. The choice of location for a public service building can consider the cost and function of the facility [21]. Decision of the location of the facilities manufacturing should evaluate the cost of transportation of materials, the source of the power of man, the cost of construction and land, and the connection utility [23]. Optimization of system layout (site layout) is a step in the planning of the facility which aims to develop a system of area efficiently and effectively so as to achieve a process that is the most optimum. Planning layout it has a function to determine and put supporting facilities the implementation of projects such as directors kit, camp workers, generators and so on at the location were right. Order location of the facility while it has the impact that is important for the process of construction projects that include time jobs, and the cost of the project is mainly on projects important which is managed by the government. Each project must have a vast land that is different each and require facilities that differ also in the implementation of the project [21].

Cost estimation is an important thing in the construction industry. Inaccuracies in estimation can have a negative effect on the construction process and for all parties involved. The definition of cost estimation the art of estimating (the art of approximating) the possible amount of costs required for an activity based on the information available at that time. Cost estimation is closely related to cost analysis, which is work that involves assessing the costs of previous activities that will be used as material for compiling cost estimates. In other words, also prepared a cost estimate is to see the future, taking into account and held estimates top of things that will probably happen [1]. Meanwhile, cost analysis focuses on assessing and discussing the costs of past activities that will be used as input. In trying to find a further understanding of cost estimation, it is necessary to take into account the relationship with cost engineering. Cost engineering is an area of engineering

activity where engineering experience and considerations are applied to the application of engineering principles and science in the problem of cost estimation and cost control [20]. Estimation analysis is a method traditionally used by estimators to determine each cost for the work component analyzed into the main components of labor, materials, equipment, workers, and others. The main emphasis is given factors - factors such as the type, size, location, shape, and height are important factors affected the construction costs [4]. Five classes of estimation are presented in relation to the characteristics identified. Only the project definition level determines the approximate class [1]. The other four characteristics are secondary characteristics that generally correlate with the level of project definition, as discussed in the general standard. Their characteristics are typical for the process industry but may vary from application to application. These matrices and guidelines provide an approximate classification system specific to the process industry. Refer to generic standards for general non-industry specific matrices, or other additions to guidelines that will provide more detailed information for applications in other specific industries. This will usually provide additional information, such as an entry submission checklist to allow meaningful categorization within that particular industry.

Most large estimates of the cost of having the characteristics of a common, regardless of whether the scope of technical traditional (funded capital, construction, purchase of equipment, etc.) Or nontraditional (financed by fees, research and development, operations, etc.). Characteristics of the most common is the level of definitions, requirements (use or destination end), and techniques that are used [1]. The level of the characteristic is generally grouped into the classification of the approximate cost. Classification estimates the cost can be used with all types of projects or the work of traditional or nontraditional and may include consideration of (1) where the project stands in the cycle of life, (2) the level of definition (the amount of information that is available), (3) the techniques to be used in the estimation (for example, parametric vs. definitive), and or (4) time constraints and other estimation variables. Usually, as a project progresses, it becomes more certain. Estimated cost of which describe a project or a job that is developing also become more definite from time to time. Determining the classification of the approximate cost to help ensure that the quality of the estimates of the cost to be considered with proper. The classification also can help determine the implementation of contingency that is appropriate, escalation, the use of cost directly / not directly (as determined by engineering estimates of the cost), etc. [1]. Other processes are : Order of magnitude. Estimates This gives procedure rules practically are applied only to the type of recurring of the installation of plants that have a history of cost that is good. Scope, Budget Authorization, or Introduction. Estimates of this, with the possibility of error by 20%, requires knowledge that is more detailed than the estimate study on the tread, flow sheet, equipment, buildings, and others. Project or Definitive Control. Estimates of this, with the possibility of an error of 10%, requiring more much information than forecast space sphere, especially regarding the location, equipment, and the requirements of electricity. Firm, Contractor, or Detail. This is the most accurate type of estimate (5% probability of error), requiring complete drawings, specifications and site surveys [39].

Factors location becomes a factor that becomes the input into the estimated costs [39]. In specific, to draw up estimates of the study, things - things the following must be known : Factory location, Location source in the factory, Parameters of design, such as the size of the source or rank capacity, the concentration of pollutants that are not controlled, the requirements of removal of pollutants, etc. A rough sketch of the process flow sheet (that is, the relative location of the equipment in the system), Initial size and material specifications for system equipment items, Estimates of the size and type of construction of any building that is needed to accommodate system control, Estimated coarse needs utilities (e.g. electricity, steam, water, and disposal of waste), The quantity and cost of materials that are consumed in the process (for example, water, reagents, and catalysts), Initial flow sheet and specifications for ducts and piping ; Approximate motor size required, Parameter economy (e.g., the level of interest yearly, the age of the equipment, the costs, and taxes.)

Prebid planning (PBP) is carried out by the contractor prior to bidding. Spatially based quantity survey procedure to increase estimator productivity [6]. The use of spatially to improve the accuracy of the estimated cost by using the data techniques are defined by either associated with an organization. Development of the method of interpolation spatial -based spatial to adjust factor cost locations to improve the accuracy of the estimated costs and can develop a tool to estimate the cost of the road [33]. During the planning of the construction, the decision was made at the level of the micro to help the crew of the field in the execution of daily operations. System determination of the position of global (GPS) and GIS to reduce the waste of construction and improve the efficiency of work. Owners generally do not have the knowledge and experience that is needed in the planning system layout sites [10]. After awarding the contract, the planning system layout sites charged to project overhead is not treated as part of the cost directly. Because of that, the planning system layout the site is an area that is overlooked from the owner. Tata layout material: Order layout material that bad cause jams site, not to the inaccessibility of the material particular, delays in the project, and swelling costs.

Proposed a material accessibility grade (MAG) to measure material accessibility throughout the project duration. The system is developed on a platform -based spatial to automate tasks such as reading inputs the user, make a list of the demand and supply of materials, calculate a value for the convenience pick, comfort delivery, track the shortest, and calculate the overall MAG to plan layout of the site [2]. According to explores the use of GIS in development planning layout sites automatically to shut down the facility while (TF) for activities supporting them, to reduce the time of travel [10]. Consists of spatial and system management database to integrate the information that is required to find the location of optimal various TF. Most spatial analysis is two-dimensional (2D) analysis, because it was, the work that is done in developing the system layout site, layout material, and space that is covered by the equipment at the site is based on the analysis of 2D [9]. Location Equipment assess proximity of the line of electricity, the population in the surrounding location, and proximity of the facilities / utilities that exist

affecting the location of equipment in one location. The efficiency of tower cranes depends on the type, number and number of locations. A planner experiencing difficulty in finding the location optimal for the crane; therefore, it operates in a zone of overlap and often have the time and the constraints of space. spatial facilitates in location optimization and 3D visualization of potential tower crane conflicts. Spatial is the case specifically of system information where the database consists of observations on the features that are distributed in spatial, activities, or events, which can be defined in space as points, lines, or areas. GIS manipulate the data of point, line, and area is take the data for inquiry and analysis [2]. Spatial is used by a group of individuals and organizations are heterogeneous for various kinds of applications. In particular, GIS has been used in the field of management of construction to resolve the problem optimization such as, for example, planning material or system layout sites [9].

Spatial can be effectively used as a system supporting the planning layout space to handle a variety of things kind of data associated with considerations layout [10]. World real abstract factors can be expressed as a matrix of cells or pixels, which is called raster map, which serves as a source of data that is set in the search for the optimal route. For example, raster maps the topography of which represents land with a slope can be made by calculating a line tangent to the surface of each cell, and the most substantial programs device software GIS is able to perform calculations like that. Function analysis of spatial GIS enables the creation, query, mapping, and analysis of raster data based cell, the derivation of information just from the data that there is, and query information across multiple layers of data. Implementation model of spatial for optimization of the location of the well on the estimated cost of the project in phases of planning can solve the problem of delay projects da n increase investment operations and maintenance in industrial mining with the valuation of the investment and the area of the project which is quite extensive. This is in line with the thinking which adjusts location cost factors to increase the accuracy of cost estimates during construction planning in implementation [33]. Project cost estimates usually include 3 inputs, including: Project management plan (cost management plan, quality management plan, scope baseline, project scope statement, work breakdown structure, WBS dictionary), Project documents (lessons learned register, project schedule, resources requirements, risk register), Enterprise or Organization (enterprise environmental factors, organizational process assets, market conditions, published commercial information, exchange rates and inflation) [40].

III. METHODOLOGY

Variable estimated cost of the variable which cause or result in the emergence or change of variables were rated on modeling. The data is used to determine variable the estimated cost of which is used is the Project Location, Project Schedule, Resources Requirement, Enterprise Environmental Factor, Scope Baseline. Variables that are used in the research is related to its relationship to business processes is the location of each individual - each unit location of the business of mining nickel upstream and downstream. The location units are, among others: Pit Location, Stockpile, Stockyard, Barging and Shipment. Characteristics of Spatial is an aspect geographically where subjects were more extensive that crosses many boundaries of formal knowledge, linking the findings in geology, climatology, agriculture, technology, and economics with several disciplines of science cognate [46]. Variable characteristics of spatial which will be built in research this is the characteristic spatial who needed to estimate smelter plant or layout projects smelter which will do the processing of advanced, among others: hydrology, topography, soils type. Variable model of spatial are used in research this is the result of the estimated cost of which is carried out by methods study the case, and variable location of the business process industry upstream and industries downstream mining nickel on a study case. Model spatial were built based on the layout plan of the project smelter nickel with the HPAL that therein has 9 locations layouts among others : Beneficiation of ore to separate chromite, Slurry treatment (thickening and preheating), High pressure acid leaching (HPAL), Recycled leaching, Fe or Al removal, Separation of solid-liquid by CCD, Precipitation of nickel / cobalt hydroxide (MHP), Filtration of MHP products and packaging, Tailings neutralization.

Research is using the collection of data with the primary data and secondary, with primary data related to the condition of the existing IRR based on a study case of the results of the analysis of the feasibility study projects smelter nickel. While for the data secondary will be taken, namely the indicator project location of the data secondary to the method of sensing far from USGS, as well as Google and Open Street Map in the input into the software QGIS, as well as the data secondary to calculate the distance of the location of business processes using the tools of measurement in software QGIS. Analysis of data using spatial analysis with analysis of statistics, analysis of correlation regression fay and Herriot models as well as the analysis of alternatives on the variables that compose the estimated costs in the determination of the percentage of accuracy estimates are generated in the smelter project industrial mining in terms of business process industry mining of nickel. The analysis was carried out in the planning phase analysis unit. Meanwhile, for the analysis of the Fay and Herriot regression model to form a spatial model for location optimization, the tools of the spatial autocorrelation model will be used in QGIS software and supported in the PostgreSQL database.

Spatial Fay and Herriot Model assumes an extension of the model Fay and Herriot classic [16], which of the coefficient of auto correlation of spatial and matrix proximity. The W matrix is the proximity matrix between the analyzed areas whereas ρ measures the strength of the spatial relationship between random effects in neighboring areas [42]. Alternative analysis is used to select corrective actions or a combination of corrective and preventive actions to be applied when a deviation occurs [40]. The purpose of alternative analysis in general, to determine the decisions that will be taken in the project, in case it can be expected choose in the alternative when the benefits are not the same and can be appreciated that with notice assumptions alternative corresponding,alternative has frame time are the same (if not, add value terminal to alternate age that much longer), Determining the feasibility economics of alternative single, as well as the IRR is great. By nature, the results of the project are given will vary change in the lives of the economy and the pattern of the flow of cash. In fact, IRR is found by letting it be the dependent variable on

cash flow and economic life [26]. Accept the project if IRR exceeds the return on which is requested. In contrast to the methods of NPV, IRR can be used to determine the ranking of investment that has a cost of initial and life are different [26]. Choose the alternative with the highest IRR. As a rating tool for investment, Analysis IRR is used in the research is intended to explain and analyze the benefits of investment are generated from a model of spatial for optimization of locations.

IV. RESULTS

In this section we discuss the experimental results based on the spatial model existing projection and new alternative location which are builds from the variable dataset. We also validate the spatial model to investment, operational and maintenance cost as an output. This research output will give spatial model to optimize location are determine based on main variables project estimate cost, geographical condition, and nickel mining business process. Fig. 1 shows the model will generate the alternative location to improve investment and operational maintenance cost based on existing cost project projection.

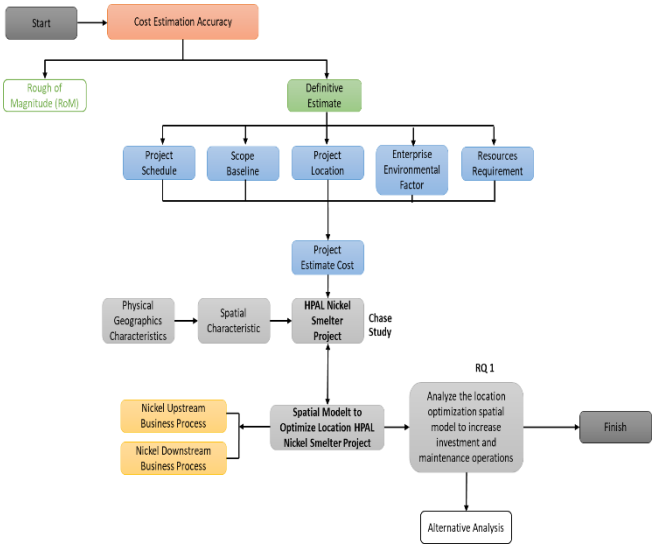

Fig. 1. Spatial Model to Optimize Location Flow

The dataset on main variables set on the PostgreSQL to easily connect to GIS software (QGIS) to generate the analysis. Based on the spatial model flow, researcher create phyton script on QGIS to build the model. The alternatives boundary will create just within the polygon of IUP (lease-to-use forest area permits) to reduce the land conflict or permitting issues. Fig. 2 show IUP polygon as a based polygon will join with all variables from project, geographical condition or spatial characteristics, and business process. After running the script on QGIS from dataset in PostgreSQL, now we have spatial model suitability as existing projection. Results will give all generate table from the variable which are joined to based polygon and possible to validate using spatial autocorrelation what variables will improve the investment and operational maintenance based on existing spatial model from main variables that used in this research and give recommendation location within the IUP as a permit area and base polygon on this research.

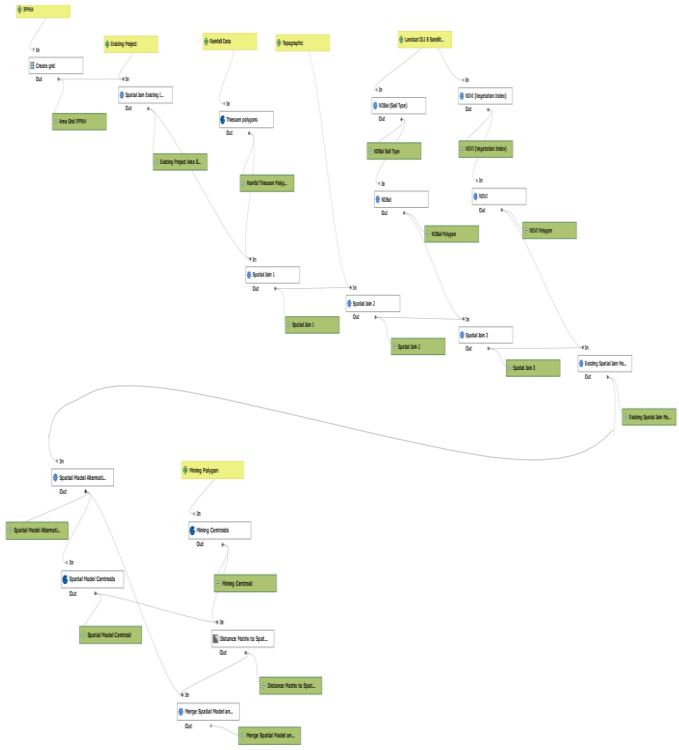

Fig. 2. Spatial Model to Optimize Location Model Builder in QGIS, IUP - lease-to-use forest area permits.

This algorithm is creating from joining the dataset to IUP as a base polygon. First step must need to synchronize the dataset to polygon shape and vector data. As given dataset, rainfall data and topographic are contains data point shape. Data points shape will extract to polygon using interpolation methods which are Thiessen Polygon, and IDW Interpolation. The extracted data points should transform and possible to join into base polygon accurately. Soil type, and vegetation index dataset are coming from satellite imagery raster data. It means transform the data to vector is the methods joining the data into the base polygon. Raster data is a little bit different transformation that need to using methods, firstly need to create map algebra to create soil type (NDbal) and vegetation index (NDVI). After the output from map algebra or raster calculation success we need to classify the value of index using raster to polygon with reclassify before, and the value of raster now turn into vector data and possible to join into the base polygon. All the datasets after crunching and transform into polygon shape, create the spatial join or join table from location with base polygon as a main polygon to generate the datasets value in the whole base polygon area. The output from joining table or spatial join gives IUP as base polygon have value and information based on the dataset that we joined before. Joined the layer to the whole IUP areas need more details to defining the HPAL nickel smelter project existing zone, using the clip or extract to the mask to get more details on that zone to possibly get the HPAL nickel smelter project existing information with information and value that we joined before. The output value shows in Table I which variables are joining and catch to the HPAL nickel smelter project existing areas.

TABLE I. SPATIAL MODEL AUTOCORRELATION

Variables	Existing Projection								
	I	II	III	IV	V	VI	VII	VIII	IX
Spatial Characteristics									
Rainfall (Avg. Monthly mm)	165.11	179.60	179.17	174.63	187.04	161.83	181.73	167.53	190.67
Topographic (Meter)	51.57	74.22	81.09	70.39	75.76	40.94	59.50	45.00	88.96
Soil Type (NDbal Index)	-0.41	-0.37	-0.37	-0.46	-0.37	-0.40	-0.40	-0.39	-0.40
Vegetation Index (NDVI Index)	0.17	0.20	0.18	0.16	0.20	0.18	0.20	0.20	0.20
Nickel Mining Business Process (Distance in Km)									
Pit Location	3.07	2.85	2.88	2.89	2.67	2.73	3.17	2.80	3.02
Stockpile	3.30	3.12	3.13	3.11	2.98	3.04	3.40	3.11	3.29
Stockyard	2.34	1.93	2.04	2.16	1.59	1.66	2.42	1.75	2.10
Barging and Shipment	2.04	2.22	2.22	2.29	2.42	2.33	1.94	2.23	2.03

a. I - Beneficiation of ore to separate chromite, II - Slurry treatment (thickening and preheating), III - High pressure acid leaching (HPAL), IV - Recycled leaching, V - Fe or Al removal, VI - Separation of solid-liquid by CCD, VII - Precipitation of nickel / cobalt hydroxide (MHP), VIII - Filtration of MHP products and packaging, IX -Tailing's neutralization).

The datasets from spatial join would generate and explain the value of each variables. Table 1 show every value contains from the dataset from the IUP as base polygon. Alternative location is determined from the value combination of the dataset within the IUP base polygon. It will take standard tolerance 5% from the existing model projection to build the new alternative polygons. The alternative polygon is calculated from the algorithm in QGIS which are give the recommendation or best investment, operational and maintenance cost through each polygon from generate the definitive estimate from alternative location itself. The new alternative location which already count the investment value such as IRR, NPV, and PBP are possible to give the project recommendation and the action plan needed if choose one of them as a project location.

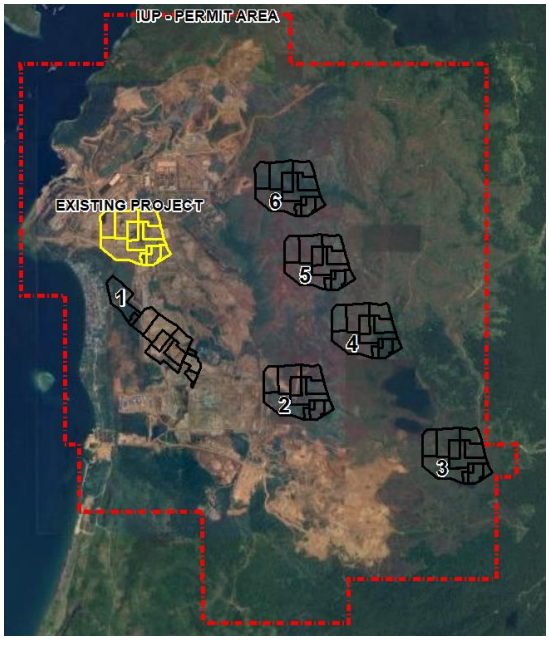

Fig. 3. Alternatives Location of HPAL Nickel Smelter Project

Vector data from HPAL nickel smelter project existing that contain value and information from joined dataset or variable need validation to determine correlation. The correlation is basically using spatial statistic methods or spatial autocorrelation model. 6 Alternatives location that built as a recommendation use the regression model to give confident level statistic. Those alternative location are validate based on 9 categories of HPAL nickel smelter project requirements to construct on that locations. The alternatives models are built from spatial models which have confident level enough to breakdown the investment value and operational maintenance cost look Fig.3.

TABLE II. ALTERNATIVE PROJECT LOCATION IRR PROJECTION

Coefficient Operation Cost	Project Location	Revenue	Capex	Debt Return	OPEX I	OPEX II	IRR
1.0000	Existing Project	592.52	684.23	123.16	92.71	198.58	17.85%
0.8828	Alternative I	592.52	684.23	123.16	81.84	175.29	19.74%
1.9504	Alternative II	592.52	684.23	123.16	180.81	387.30	-5.94%
0.4928	Alternative III	592.52	684.23	123.16	45.68	97.85	25.54%
1.1437	Alternative IV	592.52	684.23	123.16	106.03	227.11	15.40%
1.7610	Alternative V	592.52	684.23	123.16	163.26	349.70	1.41%
1.3799	Alternative VI	592.52	684.23	123.16	127.92	274.01	10.92%

a. IRR – Internal Rate of Return, Cost in Million USD, Debt Return 10 Years After Construction (8% per year), OPEX I - Opex Before Production, OPEX II - Opex After Production, Revenue and Capex Assumption same as existing project, IRR Projection 20 years until 2041, Project Start 2022

Results alternative show differentiation on IRR results based on project location. Table II shows IRR results based on the spatial model existing, and alternatives based on the research process. Various IRR contributes from project location which affect the labor cost and maintenance cost on OPEX (Operational Expenditure) and reflected on coefficient cost. Project location will affect distance and route cost for the operational from business process and HPAL nickel smelter project.

V. CONCLUSION

In this paper we investigate methods to define acceptable location using spatial model to location optimization to increase investment and operational maintenance cost. To achieve this goal, we trained dataset in database and look crunching data in GIS using python language with various spatial and temporal information. We also evaluated spatial model for location optimization of the nickel smelter project only has 33.3% (2 from 6 Location Model) chance to increase IRR in terms of investment and operational maintenance cost. However, this spatial model will increase IRR 1.89% up to 7.69% from existing project by looking the IUP permit area limits and non-built-up area as existing business process.

REFERENCES

[1] *AACE. (2005). Cost Estimate Classification System – As Applied In Engineering, Procurement, and Construction for The Process Industries. AACE International Recommended Practice No. 18R-97.*

[2] *Su, X., Andoh, A. R., Cai, H., Pan, J., Kandil, A., & Said, H. M. (2012). GIS-Based Dynamic Construction Site Material Layout Evaluation for Building Renovation Projects. Autom. Constr., 27, 40–49.*

[3] *Anderson, Keller, PC, & G., C. (2018). The Production of Critical Materials as by Products. Crimson Publishers, ISSN 2578-0255.*

[4] *Ashworth, A. (1994). Building Cost Planning. Gramedia.*

[5] *Atay, H., & Toz, G. (2011). GIS as a Planning Tool for Health and Safety Management in Linear Construction Projects. ". J. Earth Sci. Eng., 1, 132–139.*

[6] *Bansal, VK, & Pal, M. (2007). Potential of Geographic Information Systems in Building Cost Estimation and Visualization. Autom. Constr., 16 (3), 311–322.*

[7] *Bintarto. (1981). Geographic Studies An Approach and Analysis. Phibeta.*

[8] *Camp, CV, & Brown, MC (1993). GIS Procedure for Developing Three-Dimensional Subsurface Profile. J. Comput. Civ. Eng., 10.1061 / (ASCE) 0887-3801 (1993) 7: 3 (296), 296–309.*

[9] *Cheng, EW, & Li, H. (2004). Exploring Quantitative Methods for Project Location Selection. Building and Environment 39 (2004) 1467–1476.*

[10] *Varghese, K., & O'Connor, JT (1995). Routing Large Vehicles on Industrial Construction Sites. J. Constr. Eng. Manage., 121 (1), 1–12.*

[11] *Childe, S., Maull, R., & Bennett, J. (1994). Frameworks for Understanding Business Process Reengineering. International Journal of Operations & Production, 14 (12), 22-34.*

[12] *Christensen, P., & Dysert, LR (2005). Cost Estimate Classification System As Applied in Engineering, Procurement, and Construction for the Process Industries. AACE International Recommended Practice No. 18R-97.*

[13] *Couclelis, H. (1985). Cellular Worlds: A Framework for Modeling Micro — Macro Dynamics. Sage Journals.*

[14] *Thomas, HR, & Horman, MJ (2005). Role of Inventory Buffers in Construction Labor Performance. J. Constr. Eng. Manage., 131 (7), 808*

[15] *Suherman, I., & Saleh, a. R. (2018). Supply Chain Analysis for Nickel Industry. INDONESIAN MINING JOURNAL Vol. 21, No. 1, April 2018: 59 - 76.*

[16] *Fay, R., & Herriot, R. (1979). Estimates of Income for Small Places: An application of James Stein Procedures to Census Data.. Journal of the American Statistical Association, 74, 269–277. DOI: 10.1080 / 01621459.1979.10482505.*

[17] *Gould, FE (1997). Managing the Construction Process: Estimating, Scheduling, and Project Control. Prentice Hall, 1997 - Technology & Engineering.*

[18] *Hassanein, A. (2002). Planning and Scheduling Highway Construction Using GIS and Dynamic Programming. ". Ph.D. thesis, Concordia Univ., Canada.*

[19] *Hegazy, T. (2005). GIS Support for Optimizing Infrastructure Programs of Distributed Sites. Proc., 10th Int. Conf. on Civil, Structural and Environmental Engineering Computing, BHV Topping, ed., Civil Computing Press, Stirling, Scotland.*

[20] *Soeharto, I. (1995). Project Management from Conceptual to Operational. Erlangga.*

[21] *Hisham Said, S., & and Khaled El-Rayes, M. (2011). Optimizing Material Procurement and Storage on Construction Sites. J. Constr. Eng. Manage., 2011, 137 (6): 421-431.*

[22] *Hyari, KH, Al-Daraiseh, A., & El-Mashaleh, a. M. (2016). Conceptual Cost Estimation Model for Engineering Services in Public Construction Projects. J. Manage. Eng., 2016, 32 (1): 04015021.*

[23] *Ing. Radan Tomek, MI (2016). Improvement of economic effectiveness of road highway projects.. Science Direct, Creative Construction Conference 2016, CCC 2016, 2528 June 2016.*

[24] *Jeljeli, MN, Russell, JS, Meyer, HW, & Vonderohe, AP (1993). Potential applications of geographic information systems to construction industry. J. Constr. Eng. Manage., 10.1061 / (ASCE) 0733-9364 (1993) 119: 1 (72), 72–86.*

[25] *Jia, N., Xie, M., & Chai, X. (2012). Development and Implementation of a GIS-Based Safety Monitoring System for Hydropower Station Construction. J. Comput. Civ. Eng., 10.1061 / (ASCE) CP.1943-5487.0000105, 44–53.*

[26] *Kay, RD, & Edwards, WM (1994). Farm Management Third Edition. McGraw-Hill, 281–299. p.*

[27] *Shibayama, K., Yokogawa, T., Sato, H., Enomoto, M., Nakai, O., Ito, T.,.. Hattori, Y. (2016). Taganito HPAL Plant Project. Science Direct, Minerals Engineering 88 (2016) 61–65*

[28] *Laufer, A., Shapira, A., Cohenca-Zall, D., & Howell, G. (1993). Prebid and Pre-Construction Planning Process. J. Constr. Eng. Manage., 10.1061 / (ASCE) 0733-9364 (1993) 119: 3 (426), 426–444.*

[29] *Le, C., Tuyen Le, A., H. David Jeong, A., & Lee, a. E. (2019). Geographic Information System – Based Framework for Estimating and Visualizing Unit Prices of Highway Work Items. J. Constr. Eng. Manage., 2019, 145 (8): 04019044.*

[30] *Zhong, D., Li, J., Zhu, H., & Song, L. (2004). Geographic Information System based Visual Simulation Methodology and Its Application in Concrete DAM Construction Processes. J. Constr. Eng. Manage., 10.1061 / (ASCE) 07339364 (2004) 130: 5 (742), 742–750.*

[31] *McDonald, R., & Whittington, B. (2008). Atmospheric Acid Leaching of Nickel Laterites Review. Part I. Sulfuric Acid Technologies. Hydrometallurgy, 91, 35-55.*

[32] *Meester, LD (1999). Environmental Stress and Local Adaptation in Daphnia magna. ASLO.*

[33] *Migliaccio, GC, Zandbergen, P., & Martinez, AA (2013). Empirical Comparison of Methods for Estimating Location Cost Adjustments Factors. J. Manage. Eng., 10.1061 / (ASCE) ME.1943-5479.0000240, 1–10.*

[34] *Mudd, GM (2010). Global trends and environmental issues in nickel mining: Sulfides versus laterites. Ore Geol. Rev. 2010, 38, 9–26.*

[35] *Oloufa, AA, Eltahan, A., & Papacostas, C. (1994). Integrated GIS for Construction Site Investigation. J. Constr. Eng. Manage., 10.1061 / (ASCE) 0733-9364 (1994) 120: 1 (211), 211–222.*

[36] *Park, T., Kang, T., Lee, Y., & Seo, K. (2014). Project Cost Estimation of National Road in Preliminary Feasibility Stage Using BIM / GIS Platform. Proc., ASCE Int. Conf. on Computing in Civil and Building Engineering, ASCE, Reston, VA, 423–430.*

[37] *Patunru, A. (2015). Downstream. Kompas Gramedia.*

[38] *Pellenbarg. (2006). The Spatial Preference Map of Dutch Entrepreneurs. Tijdschrift voor Economische en Sociale Geografie 104 (1).*

[39] *Perry, RH, & Chilton, CH (2008). Perry's Chemical Engineers' Handbook (Eighth Edition). McGraw-Hill, New York, 2008.*

[40] *PMBOK. (2017). A Guide to the Project Management Body of Knowledge. PMBOK Sixth Edition - Project Management Institute, Inc.*

[41] *Porter, EM (1985). Competitive Advantage-Creating and Sustaining Superior Performance. New York: Free Press..*

[42] *Pratesi, M., & Salvati, N. (2008). Small Area estimation: The EBLUP Estimator Based on Spatially Correlated Random Area Effects.. Statistical Methods and Applications, 17 (1), 113–141. DOI: 10.1007 / s10260-007-0061-9.*

[43] *Reid, JG (1996). Laterite Ores - Nickel and Cobalt Resources for the Future. Proceedings Nickel '96 Mineral to Market (eds: EJ Grimsey and I Neuss), pp 11-16.*

[44] *Richard L, D. (2007). Management Edition 1. Translated by Edward Tanujaya and Shirly Tiolina. Four Salemba.*

[45] *Rudenno, V. (2004). The Mining Valuation Handbook. 2nd edition. Rightbooks an Imprint of John Wiley and Sons Australia, Ltd.*

[46] *Setiadi, H. (2008). Historical Geography and Mapping. FMIPA, University of Indonesia.*

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