A Resource Planning Strategy Model for Improving Geospatial Data and Information Quality: A Case Study of PT. XYZ

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ABSTRACT: *Along with the advancement of technology, geospatial has been widely used for various needs in various sectors, including construction industry. The role of geospatial in presenting quality data and information has an important role in assisting decision making and/or implementation of activities. However, previous research has focused more on technological aspects than on geospatial resource planning. This study aims to develop and test a resource planning strategy model that explains how geospatial resource aspects such as equipment/technology, implementation methods, and human resources contribute to resource planning strategy and how its strategy affects geospatial data and information quality in infrastructure projects. The study was conducted using a quantitative approach through questionnaires to PT XYZ practitioners who are related to geospatial management. Respondents were selected using a purposive sampling technique and analyzed using homogeneity, validity, reliability, correlation, and linear regression tests. The research model shows that equipment/technology and implementation methods have a significant influence on resource planning strategy rather than human resources. The strategy has also proven to have a significant influence on geospatial data and information quality. These findings can be used as a basis for developing practical planning strategies for managing geospatial resources, especially in infrastructure construction projects.*

KEYWORDS *– Data and Information Quality, Geospatial, Relationship Model, Resource Planning, Strategy*

I. INTRODUCTION

Along with the advancement technology, the use of geospatial, which was initially only used for map making needs, now is widely used for various needs. There are seven related activities related to geospatial, starting from positioning, surveying and mapping; navigation, tracking, and reconnaissance; earth observation and modeling; imaging and scanning; GIS, spatial analysis and modeling; spatial planning and design; and digital twins and the metaverse [1], as shown in Fig.1.

Fig. 1 Geospatial related activities (Adapted from: Abidin, 2022)

In the construction industry, the use of geospatial has been widely used for various infrastructure project needs, such as topographic modeling [2], regional planning [3], building construction [4], Road Infrastructure [5], tunnels [6], underground utility mapping [7], monitoring physical construction progress [8], landslide monitoring for safety [9], to monitoring construction resources [10]. According to [11] Geospatial is a spatial aspect that shows the location, place, and position of an object or event that is below, on, or above the earth's surface which is expressed in a certain coordinate system. Therefore, the infrastructure construction industry cannot be separated from the geospatial aspect.

However, based on previous study, there were several problems that are still found in terms of geospatial management, as shown in Table 1.

Table 1. Geospatial Problems List

No.	Problems	Ref.
1	Surveyor competencies does not meet with project requirements.	[12]
2	Differences in measurement methods and results between projects.	[13] & [14]
3	Use of inappropriate measurement tools/technology.	[2], [15], [16]
4	Missing or incomplete reference and supporting data, such as utilities and as-builts.	[7], [17], [13]
5	Delays in data or measurement activities within the project.	[8], [18]
6	Choosing inexpensive survey methods (despite low accuracy).	[2], [19]
7	Data updates that are not real-time, along with long acquisition and processing times.	[6], [20]

If reviewed further, there are several causes of the main problems of geospatial management in infrastructure construction projects, which can be seen in Table 2.

Table 2. List of Geospatial Problem Causes

No.	Causes	Ref.
1	Gap between human resource (surveyor) competencies and the needs of the construction industry.	[12], [21]
2	Lack of ongoing training to master the latest equipment/technology.	
2	No national standards for the implementation of several measurement methods.	[13], [14]
3	Technical limitations of each geospatial tool/technology.	[2], [15], [16]
4	Poor data recording processes.	[7], [17]
5	Weak coordination among project stakeholders.	[18], [8]
6	Pressure on geospatial survey budgets.	[19], [2]
7	Limitations on workflow and data integration.	[6], [20]

From the research that has been conducted previously, there are still several gaps in the research that has been carried out as shown in Table 3.

Table 3. Previous Research Gap

No.	Gap	Ref.
1	There is a lack of competency studies related to human resources or geospatial experts according to the needs of the construction industry.	[12], [21]
2	There is still limited research related to the relationship between geodesy and construction management stakeholders.	
3	There are no standardization or clear guidelines for implementing implementation methods.	[13], [14]
4	There is limited research related to national strategies for geospatial resource planning.	[7], [22]
5	There is still a focus on one tool/technology system for one measurement object.	[2], [15], [16]
6	Low adoption of expensive new technologies in developing countries.	[7]
7	There is no research related to Cost-Benefit Analysis for selecting geospatial technology in infrastructure projects.	[2], [16], [19]
8	There is limited research related to UAV-BIM automation.	[8], [20]

9	There is little quantitative discussion of the relationship between geospatial data quality and DTM/BIM model quality.	[17]
10	Automation of point cloud–BIM–GIS integration is still rare.	[6], [20]

From several gaps found in previous research, this research was conducted to fill the gaps related to strategies in geospatial resource planning. This research was conducted at PT XYZ, which is one of the companies providing infrastructure project construction services in Indonesia.

The aim of this research is to develop and test a resource planning strategy model that explains how geospatial resource aspects such as equipment/technology, implementation methods, and human resources contribute to resource planning strategy and how its strategy affects geospatial data and information quality in infrastructure projects, especially at PT XYZ and similar construction service organizations.

II. Literature Review

2.1 Geospatial Data and Information

According to [23], geospatial data or information is data that identifies the geographic location and characteristics of natural or artificial features and boundaries on Earth. Therefore, all activities that are related to positions in the earth's space (including construction activities), geospatial is something that is very important to pay attention to and requires good management. Meanwhile, according to [11], Geospatial Data (GD) is data about the geographic location, dimensions or sizes, and/or characteristics of natural and/or man-made objects that are under, on, or above the earth's surface; Geospatial Information (GI) is GD that has been processed so that it can be used as a tool in formulating policies, making decisions, and/or implementing activities related to the earth's space.

2.2 Geospatial Resources Management

Resources in a project are important elements that support all project implementation activities, from the planning, implementation, to supervision stages. According to [24], resources include everything used to achieve project objectives, including people, equipment, materials, technology, and funds.

To produce good geospatial information, quality geospatial data is required [26]. Therefore, to obtain quality geospatial data, there are three main aspects that need to be managed well, such as geospatial equipment/technology, implementation methods, and human resources. From the geospatial equipment/technology side, the continuous evolution of geospatial instruments and software has increased the efficiency and accuracy of spatial data acquisition and processing [25]. In terms of implementation methods, the success of geospatial projects depends on a well-structured workflow that integrates the stages of data collection, processing, and interpretation [23]. In Indonesia, several geospatial implementation methods have been outlined in existing national standards [27]. In addition, to produce the best and most complete Geospatial data and Information, a sufficient number of competent, professional, and integrity Geospatial human resources are required [1], which is proven by professional competency certification, in accordance with existing standards/ guidelines [28]. Therefore, the relationship between these aspects can be illustrated in Fig. 2.

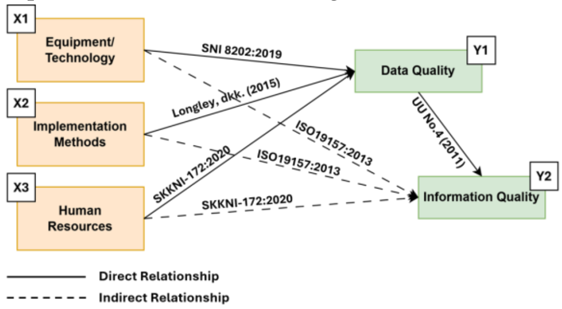

Fig. 2 Geospatial variables relationship

Based on Fig. 2, equipment/technology (X1), implementation method (X2), and human resources (X3) will be independent variables in influencing the results of the dependent variables in the form of data quality (Y1) and information quality (Y2).

2.3 Research Model

Based on Fig. 2, equipment/technology, implementation methods, and human resources are related to the quality of geospatial data and information. However, the quality of the data and information produced is not only determined by the availability and how sophisticated/modern the equipment/technology resources used are, but also by how well these resources are planned and managed. Resource planning, which includes geospatial equipment/technology, implementation methods, and human resources, is a key factor in ensuring that every geospatial management activity can be carried out effectively and according to the standards used, starting from the data acquisition process, data processing, to the presentation of geospatial data and information. Therefore, in this study, the resource planning strategy will be used as a mediator (X4) that connects the independent variables with the dependent variable. Therefore, the research concept model that will be discussed in this study is shown in Fig. 3.

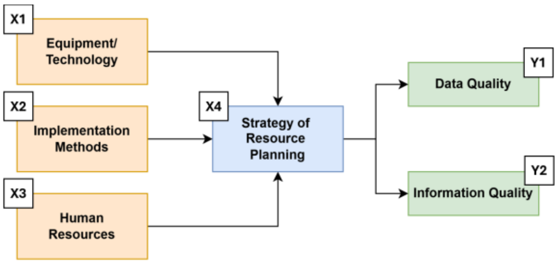

Fig. 3 Research Model

Based on Fig. 3, there are five hypotheses that can be raised in this study, including the following:

- **H1**: Geospatial equipment/technology resources have a positive influence on the development of geospatial resource planning strategy;
- **H2**: Geospatial implementation methods have a positive influence on the development of geospatial resource planning strategy;
- **H3**: Human resources have a positive influence on the development of geospatial resource planning strategy;
- **H4**: Geospatial resource planning strategy has a positive influence on geospatial data quality;
- **H5**: Geospatial resource planning strategy has a positive influence on geospatial information quality.

III. RESEARCH METHODOLOGY

3.1 Research Design

This research was conducted using a case study method at PT XYZ with a quantitative approach. The data collection in this study used an instrument in the form of a questionnaire survey of respondents at PT XYZ.

3.2 Population and Samples

The population in this study is PT XYZ employees who are related to geospatial aspects of infrastructure projects and number around 100-120 people, which can consist of Chief Survey or Survey Coordinator, Engineering Team, BIM Team, Construction Team, and Quality Control (QC) Team. Respondent selection was carried out using purposive sampling techniques to ensure that the respondents involved have experience or understanding in geospatial management carried out in the PT XYZ environment, so that they can provide a comprehensive perspective on the object being studied [29].

3.3 Variables, Dimensions, and Indicators

Based on the literature review and expert validation that has been carried out, the dimensions and indicators representing the variables with a total of 59 indicators will be displayed in Table 4.

Table 4. Research Variables, Dimensions, and Indicators

Code	Variables, Dimensions, Indicators
X1	**Equipment/Technology**
X1.1	**Availability and Usability**
X1.1.1	Availability of survey equipment and accessories according to the type of work
X1.1.2	Usability of survey equipment and accessories
X1.2	**Compliance with Technical Specification**
X1.2.1	Compliance with equipment technical specifications to the accuracy requirements of the work
X1.2.2	Compliance with equipment with the characteristics and complexity of the work
X1.3	**Calibration System**
X1.3.1	Survey equipment calibration system
X1.4	**Capability and Technological Support**
X1.4.1	Availability of data processing software

X2	**Implementation Methods**
X2.1	**Measurement Methods**
X2.1.1	Availability of standards/guidelines measurement method
X2.1.2	Consistency of application measurement method
X2.2	**Reference and Control Point Management**
X2.2.1	Availability procedures for checking measurement reference points
X2.2.2	Measurement control network plan
X2.2.3	Installation of control points
X2.2.4	Documentation of control network
X2.3	**Measurement Data Processing and Verification**
X2.3.1	Measurement data processing system
X2.3.2	Verification and validation mechanism for measurement result
X2.4	**Measurement Data Documentation System**
X2.4.1	Standard format for recording and reporting measurement results
X2.4.2	Documentation management for measurement result
X2.4.3	Integration of geospatial data into project digitalization systems
X3	**Human Resources**
X3.1	**Geospatial Technical Competencies**
X3.1.1	Basic understanding of geospatial measurement concepts
X3.1.2	Ability to process and analyze data
X3.1.3	Ability to control the quality of measurement results
X3.1.4	Ability to conduct technical survey planning
X3.1.5	Ability to adapt to digital technology
X3.1.6	Possession of professional competency certification
X3.2	**Background and Experience**
X3.2.1	Suitability of educational background to the geospatial field
X3.2.2	Work experience in surveying/geospatial fields
X3.3	**Professionalism and Work Behavior**
X3.3.1	Technical problem solving and decision-making skills
X3.3.2	Accuracy and consistency in survey implementation
X3.3.3	Technical communication skills related to measurement results
X3.4	**Competency Development System**
X3.4.1	Availability of internal training programs
X3.4.2	Personnel participation in training
X3.4.3	Clarity of technical roles and responsibilities according to job level
X4	**Resource Planning Strategy**
X4.1	**Equipment/Technology Planning**
X4.1.1	Analysis of geospatial equipment/technology needs based on work characteristics
X4.1.2	Determination of geospatial equipment/technology specifications
X4.1.3	Determination of equipment/technology integration needs in geospatial data management
X4.1.4	Planning for managing the use of geospatial equipment/technology
X4.1.5	Planning maintenance and calibration of geospatial equipment/technology
X4.1.6	Evaluation and development of geospatial equipment/technology
X4.2	**Implementation Methods Planning**
X4.2.1	Analysis of geospatial implementation method needs based on work characteristics
X4.2.2	Determination of geospatial measurement methods and parameters
X4.2.3	Planning the implementation workflow of survey methods
X4.2.4	Planning of quality control mechanisms for geospatial implementation methods
X4.2.5	Planning documentation and presentation needs for measurement results
X4.3	**Human Resource Planning**
X4.3.1	Manpower needs analysis
X4.3.2	Determining the required manpower competency
X4.3.3	Planning the division of roles and responsibilities within the survey team
X4.3.4	Planning the development of geospatial human resource competencies
X4.3.5	Planning the performance evaluation of manpower
Y1	**Data Quality**
Y1.1	**Data Accuracy & Precision**
Y1.1.1	Conformity of measurement results to established tolerances or standards
Y1.2	**Data Consistency & Reliability**

Y1.2.1	Consistency between repeated measurement results
Y1.3	**Data Completeness & Adequacy**
Y1.3.1	Data completeness or adequate according to requirements or needs
Y1.3.2	Completeness of supporting data attributes/information
Y1.4	**Data Traceability**
Y1.4.1	Documented data re-traceability
Y1.5	**Data Structure & Format Conformity**
Y1.5.1	Uniformity of data structure/format in supporting the interoperability of the digital systems used
Y2	**Information Quality**
Y2.1	**Information Accuracy & Precision**
Y2.1.1	Information accuracy in representing actual conditions/positions
Y2.2	**Information Usefulness & Relevance**
Y2.2.1	Information relevance to user needs
Y2.2.2	Information utilization in decision-making
Y2.2.3	Timeliness in information presentation
Y2.3	**Clarity of Presentation and Understandability**
Y2.3.1	Clarity of format and visualization of information
Y2.3.2	Ease of interpretation for information users

3.4 Data Analysis Methods

The research data obtained from the questionnaire will be analyzed using SPSS version 32 through the following sequential multi-stage process:

(1) Homogeneity Test: using the Kruskal-Wallis H Test to verify that respondent groups (based on education level, job level, and work experience) do not show statistically significant differences in perception. Data is considered homogeneous when the Asymp Sig. > 0.05 for all groups. [30];

(2) Validity Test: used to determine whether the instrument used can measure variables according to their intended function. A statement item is considered valid if the Corrected Item-Total Correlation (CITC) value is > 0.30. [31];

(3) Reliability Test: used to determine the level of consistency of the research instrument in measuring a variable. A construct or variable is considered reliable if it produces a Cronbach's Alpha value > 0.60 [31];

(4) Correlation Analysis: using Pearson Correlation to determine the direction and value of the correlation coefficient (r) between the resulting variables. The correlation value has a range of $\pm 0.00 \leq r \leq \pm 1.00$, where the closer the value is to ±1.00, the stronger the relationship between variables. [29];

(5) Regression Analysis: used to measure the strength of the relationship between two or more variables, and to show the direction of the relationship between the independent variables and the dependent variable [31]. Since the relationship model analysis uses SPSS software, the regression analysis of the relationship model in this study will be conducted in several stages according to the research concept model (Fig. 3), which is divided into three main models:

- **Model A**: X1, X2, X3 → X4;
- **Model B**: X4 → Y1;
- **Model C**: X4 → Y2;

However, an additional model will be tested to examine the relationship between X4 and both dependent variables (Y1 & Y2) combined into one (Y-Total), so that:

- **Model D**: X4 → Y-Total.

Since model A has 3 independent variables, the analysis will be carried out using Multiple Linear Regression analysis, while models B, C, and D will use Simple Linear Regression analysis. Several relationship models will be analyzed based on several test results, including:

(a) The coefficient of determination (R^2) is used to measure the model's ability to explain variation in the dependent variable. The greater the R^2 value, the better the relationship model formed in explaining the relationship between research variables [31];

(b) The F-test is used to examine the simultaneous influence of independent variables on the dependent variable. In the F-test, the relationship model is considered suitable for use when it has a Sig value < 0.05 [31].

(c) The t-test is used to determine the partial influence of each independent variable on the dependent variable. Variables with good significance for the relationship model are those with a Sig value < 0.05 [31];

All statistical analyses were conducted using a 5% significance level.

IV. Result

4.1 Respondents Profile

From the results of data collection, there were 31 respondents involved in this study, which number has met the minimum respondent target of 10-15% of the population [32] and the minimum requirements for conducting statistical tests [29]. The collected respondent data is grouped into three categories, namely education level, job level, and work experience. Based on education level, the collected respondents are divided into 3 groups, namely 10% Masters, 74% Bachelors, and 16% High School or Vocational School. Based on job level, the collected respondents are divided into 3 groups, namely 6% Managers, 52% Coordinators, and 42% Staff. Meanwhile, based on work experience, the collected respondents are divided into 3 groups, namely 39% 5-10 years, 48% 10-15 years, and 13% more than 15 years.

4.2 Homogeneity Test Result

The results of the homogeneity test for the collected data can be seen in Table 5.

Table 5. Homogeneity Test Result

Var	Asymp Sig Range		
	Education Level	Job Level	Work Experience
X1	0.111~0.771	0.288~0.995	0.160~0.865
X2	0.226~0.921	0.082~0.444	0.088~0.986
X3	0.114~0.917	0.065~0.970	0.078~0.988
X4	0.066~0.980	0.064~0.872	0.122~0.911
Y1	0.076~0.924	0.185~0.840	0.207~0.934
Y2	0.103~0.886	0.051~0.940	0.056~0.963

Based on homogeneity test on Table 5, the data obtained from the questionnaire has an Asymp Sig > 0.05, which means the data obtained is declared homogeneous for each respondent category for each indicator. This condition indicates that there is no extreme variation in responses among the respondents involved. Therefore, it can be used in the next stage of data processing.

4.3 Validity & Reliability Test Result

The results of the validity and reliability tests on the collected data can be seen in Table 6.

Table 6. Validity & Reliability Test Result

Var	N of Indicators	Range of Corrected Item-Total Correlation	Cronbach's Alpha (α)
X1	6	0.566~0.862	0.873
X2	11	0.579~0.830	0.927
X3	14	0.410~0.864	0.910
X4	16	0.408~0.878	0.951
Y1	6	0.479~0.852	0.899
Y2	6	0.426~0.695	0.832

According to Table 6, each indicator used in this study had a CITC > 0.30, indicating that all indicators were valid. The reliability test results showed that all variables had an α > 0.60, indicating that the constructs used in this study were reliable and had a good level of consistency or stability.

4.4 Correlation Analysis Result

The results of the correlation analysis between variables in this study can be seen in Table 7.

Table 7. Correlation Analysis Result

Variable Relationship	Correlation (r)	Interpretation
X1 ↔ X4	0.877	Very Strong (+)
X3 ↔ X4	0.860	Very Strong (+)
X2 ↔ X3	0.844	Very Strong (+)
X1 ↔ X3	0.826	Very Strong (+)
X2 ↔ X4	0.817	Very Strong (+)
X4 ↔ Y2	0.728	Strong (+)
Y1 ↔ Y2	0.715	Strong (+)
X3 ↔ Y1	0.690	Strong (+)
X4 ↔ Y1	0.684	Strong (+)
X1 ↔ X2	0.676	Strong (+)
X3 ↔ Y2	0.596	Moderate (+)
X1 ↔ Y2	0.590	Moderate (+)
X2 ↔ Y1	0.579	Moderate (+)
X2 ↔ Y2	0.523	Moderate (+)
X1 ↔ Y1	0.517	Moderate (+)

Based on Table 7, the relationship between variables X1, X2, and X3 with X4 has a very strong positive relationship. Furthermore, the strongest relationship to the dependent variable (Y1 and Y2) is derived from X4. This proves that X4 is suitable to be used as a mediator that bridges the independent variables (X1, X2, and X3) with the dependent variables (Y1 and Y2).

4.5 Regression Analysis Result

The regression analysis conducted in this study used two different methods. Since model A will test the strength of the relationship between three independent variables and one mediator variable (which is considered the dependent variable in this model), the analysis of model A uses multiple linear regression analysis, which the results can be seen in Table 8.

Table 8. Regression Analysis Result of Model A

Model A	R^2	F test (Sig.)
	0.863	< 0.001
Variable	**t-test (Sig.)**	
X1	<.001	
X2	0.012	
X3	0.551	

From Table 8, model A has R^2=0.863 which indicates a very strong relationship model in explaining the relationship between geospatial resource variables (X1, X2, and X3) with the planning strategy variable (X4). In addition, from the F test on model A, Sig. < 0.001 was obtained, which indicates that model A is very suitable for use. However, from the t-test on model A, there are variations signification in variables X1, X2, and X3, where X1 and X2 have Sig. < 0.05, while X3 has a Sig. > 0.05. This indicates that variables X1 and X2 have a positive influence on the development of X4, while variable X3 does not have a positive influence on X4.

Meanwhile, in models B, C, and D which only have one independent variable (represented by the mediator variable or X4) against the dependent variable (Y1/Y2/Y-Total), the analysis of the three models uses simple linear regression analysis, which the results can be seen in Table 9.

Table 9 Regression Analysis Result of Model B, C, and D

Model	R^2	F test (Sig.)	t-test (Sig.)
Model B	0.468	< 0.001	< 0.001
Model C	0.530	< 0.001	< 0.001
Model D	0.571	< 0.001	< 0.001

From Table 9, all F-test results have Sig. <0.001, and all t-test results have Sig. <0.001. It indicates that these three models are suitable for use in modeling and demonstrate a positive relationship between X4 and the Y variables, both Y1, Y2, and Y-Total. However, based on the strength of the relationship, Model B (X4 → Y1) only has moderate strength (R^2=0.468). Meanwhile, Model C (X4 → Y2) and Model D (X4 → Y-Total) have strong relationships between the variables, with Model C (R^2=0.530) and Model D (R^2=0.571). This indicates that the resource planning strategy (X4) will only have a moderate impact on data quality (Y1) and a strong impact on information quality (Y2). However, if both Y variables are viewed as a whole or combined (Y-Total), X4 will have a stronger impact than if the Y variables are viewed in partially.

Based on the results of the regression analysis obtained from these four models, especially from t-test result, the answers to the existing hypotheses are as follows:

- **H1** (X1 → X4): Accepted;
- **H2** (X2 → X4): Accepted;
- **H3** (X3 → X4): Not Accepted;
- **H4** (X4 → Y1): Accepted;
- **H5** (X4 → Y2): Accepted.

In addition, based on the regression analysis, the best relationship model between geospatial resource variables (X1, X2, and X3) with the quality of geospatial data (Y1) and information (Y2) is to place the resource planning strategy (X4) as a mediator, which views the aspects of data quality and geospatial information quality as a single unit (not viewed separately). The relationship model produced in this study can be seen on Fig.4.

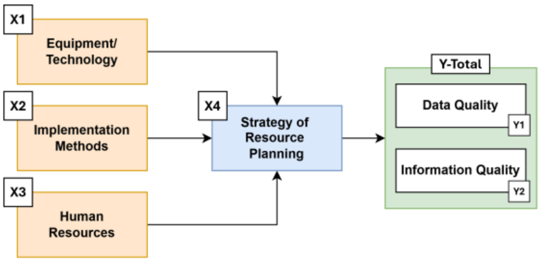

Fig. 4 Finding research model

V. Discussion

The role of resource planning strategy (X4) is appropriate when positioned as a mediator connecting geospatial resources, such as equipment /technology (X1), implementation methods (X2), and human resources (X3), with the quality of geospatial data (Y1) and information (Y2). This finding aligns with [33], which states that project resources (both human and physical resources) need to be managed properly. In the management plan, the availability of existing resources must be identified first, as evidenced by the relationship model formed in Fig. 4. This is also supported by the correlation analysis result, which proves that the resource variables (X1, X2, and X3) produce a very strong positive relationship with the resource planning strategy variable (X4), which then produces a strong positive relationship with the quality of geospatial data (Y1) and information (Y2).

In the formation of resource planning strategy (X4), equipment/technology (X1) and implementation methods (X2) are the most influential aspects compared to the human resources aspect (X3). This is because these two aspects are key to implementing geospatial management activities, some of which are regulated by existing regulation and standards [11 & 27]. The human resources involved act as executors in implementing existing physical resources, both in operating the equipment/ technology and running the implementation methods. This is confirmed by the findings of the t-test which indicate the existence of multicollinearity or a relationship between human resources with the other two independent variables. Therefore, this needs to be mitigated by having good human resource management to support the geospatial management carried out [28].

However, the results of the regression analysis found that the development of resource planning strategy has a stronger relationship with geospatial quality (a combination of data quality and geospatial information quality), compared to data quality and information quality standing alone. This is because geospatial data will be an input to geospatial information [11], so that poor data will produce poor information. Meanwhile, poor information does not always have poor data quality. Therefore, the relationship model obtained from this study indicates that geospatial resource planning strategies must consider both aspects of quality simultaneously.

VI. Conclusion

Based on the research that has been conducted, the model developed in this study successfully explains the relationship between geospatial management resources and the quality of geospatial data and information, with the role of resource planning strategy as a mediator. Equipment/technology resources and implementation methods have a significant influence on the resource planning strategy developed. The existence of a resource planning strategy has a significant impact on the quality of geospatial data and information separately. However, this resource planning strategy will be better if it considers geospatial data and information quality in one complete system, not separately.

VII.Acknowledgements

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