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Expert system for poverty level assessment using the certainly factor method

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Abstract

Poverty is one of the social problems that remains a major concern in national development in Indonesia. The process of determining poverty levels is generally conducted using several socio-economic indicators such as per capita expenditure, education level, sanitation conditions, and access to health services. However, the classification process is often performed manually, causing inconsistencies in determining poor communities. This study aims to develop an expert system for poverty level classification using the Certainty Factor method. The method is applied to handle uncertainty in the decision-making process by combining several socio-economic indicators into a confidence value for classification results. The research stages include data collection, preprocessing, data transformation, rule-based knowledge construction, inference process, and result analysis. The results show that the Certainty Factor method can be implemented in an expert system to classify poverty levels more objectively and systematically. Based on testing, the combination of low expenditure, medium Human Development Index, and poor sanitation produced a Certainty Factor value of 0.952, indicating a high confidence level in the poor category. The developed system is expected to support decision-making in poverty alleviation programs and social assistance distribution.

1. Introduction

Poverty is a social problem that remains a major concern in national development in Indonesia. High poverty rates can impact people's quality of life, increase social inequality, and hinder a country's economic growth [1]. In addition to impacting the community's economic condition, poverty is also related to limited access to education, health care, sanitation, and employment opportunities. Therefore, addressing poverty is a key priority in efforts to improve public welfare equitably.

Poverty assessments are generally conducted using various socioeconomic indicators, such as per capita expenditure, housing conditions, education levels, access to sanitation, and public health conditions [2]. These indicators are used to describe the level of community welfare in a particular area. However, in practice, the poverty assessment process is often carried out manually and relies on the interpretation of field officers. This results in a lack of consistency in the poverty classification process, potentially leading to errors in determining social assistance recipients.

Inaccuracies in the poverty classification process can result in social assistance programs not being distributed optimally. People who should receive assistance may be overlooked, while those who do not meet the criteria may receive assistance. These conditions indicate that the process of assessing poverty levels requires a system capable of assisting in more objective, systematic, and measurable decision-making. Developments in information technology provide opportunities to build artificial intelligence-based systems to support the decision-making process. One approach that can be used is an expert system. An expert system is a branch of artificial intelligence designed to mimic the ability of an expert to solve a

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specific problem [3]. Expert systems operate using a knowledge base and inference rules, enabling them to generate decisions based on data or symptoms provided by the user.

In expert systems, inference methods play a crucial role in determining decision outcomes. One widely used inference method is the Certainty Factor (CF). The Certainty Factor method is used to refine the decision-making process [4]. This method provides a confidence level for a hypothesis based on a combination of available evidence or symptoms. The higher the resulting Certainty Factor value, the higher the level of confidence in the resulting decision. The Certainty Factor method is considered appropriate for poverty assessment because a community's socioeconomic condition cannot be determined by a single indicator. For example, a community with low expenditure is not necessarily classified as poor if they still have good education and access to healthcare. Conversely, communities with poor sanitation can achieve higher levels of well-being if supported by adequate economic indicators. Therefore, a method capable of combining various indicators into a single confidence level for classification results is needed.

Several previous studies have used the Certainty Factor method in various fields, such as disease diagnosis, damage identification, and decision support systems [5], [6]. These research results indicate that the Certainty Factor method is capable of providing a level of confidence in a decision based on the combination of symptoms entered into the system. Furthermore, this method is also considered capable of assisting the decision-making process in conditions where data contains significant information. Extensive research on poverty classification has also been conducted using various approaches, such as statistical methods and data classification algorithms [7]. However, most of these studies only produce final categories without providing a level of confidence in the classification results. Confidence in decisions is crucial for assisting the evaluation process and making more accurate policy decisions.

Based on these issues, this study aims to develop a poverty assessment system using the Certainty Factor method. The developed system utilizes socioeconomic indicators as the basis for the inference process to determine the level of confidence in poverty categories. With this system, it is hoped that the poverty level classification process can be carried out more objectively, consistently and transparently so that it can help.

1.1.Releated Work

Research on poverty levels has been extensively conducted using various approaches, including statistical methods, data classification, and decision support systems. These studies demonstrate that poverty is a multidimensional problem influenced by numerous social and economic factors. Therefore, the process of classifying poverty levels requires indicators capable of describing the overall welfare of society. In addition to statistical approaches, advances in information technology have also encouraged the use of artificial intelligence-based systems in decision-making. One widely used approach is expert systems. Expert systems enable more systematic decision-making because they utilize a rule-based approach and inference processes to generate decisions based on available data.

The Certainty Factor method is one method frequently used in expert systems due to its ability to handle the inference process. This method works by assigning a confidence value to a hypothesis based on available evidence. The use of the Certainty Factor method is considered appropriate for cases with numerous indicators and elements in the classification process. Several previous studies have shown that the Certainty Factor method can be used in various expert system applications, such as disease diagnosis, problem identification, and decision support systems. The results of this study indicate that the Certainty Factor method can provide a level of confidence in decision-making outcomes, making the classification process more informative and measurable.

In the context of poverty classification, the use of socioeconomic indicators is a crucial factor in determining decision outcomes. Variables such as per capita expenditure, education level, sanitation conditions, and access to healthcare are related to community welfare. Therefore, using multiple indicators simultaneously can produce a more accurate classification process than using a single indicator alone. Based on several previous studies, it is clear that the Certainty Factor method has the potential to be applied to expert systems for assessing poverty levels. However, research on the application of the Certainty Factor method using integrated socioeconomic indicators is still relatively limited. Therefore, this study was

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conducted to develop a poverty assessment system using the Certainty Factor method, utilizing several socioeconomic indicators as the basis for the inference process.

2. Research Methodology

This research uses a quantitative approach with a Certainty Factor-based expert system development method. The research process involves several stages: data collection, data pre-processing, rule formation, inference, and analysis of the results.

2.1. Dataset and Data Characteristics

The dataset used in this study was obtained from the Central Statistics Agency (BPS) and the open dataset platform Kaggle. The dataset comprises several socioeconomic indicators related to community well-being. The variables used in this study include per capita expenditure, the Human Development Index (HDI), access to adequate sanitation, access to adequate drinking water, the open unemployment rate, and Regional Gross Domestic Product (GDP).

In the initial stage, an attribute selection process was conducted to determine the variables most relevant to the classification of poverty levels. Next, the numerical data was transformed into categorical data through a discretization process. For example, the per capita expenditure variable was categorized as low, medium, and high. The sanitation variable was categorized as good and poor. Data transformation was performed to facilitate the representation of data as symptoms in an expert system. Furthermore, this study used binary classification labels, with a value of 0 for the non-poor category and a value of 1 for the poor category.

2.2. Metode Centainty Factor

The Certainty Factor method is used to calculate the level of confidence in a hypothesis based on available evidence. Certainty Factor values range from 0 to 1. The closer the value is to 1, the higher the level of confidence in a decision.

$$CF(H,E) = CF(E) \times CF(rule)$$

Description:

1. CF(H,E) = confidence value for the hypothesis
2. CF(E) = confidence value for the evidence
3. CF(rule) = confidence value for the rule

If there is more than one piece of evidence, the combination process is carried out using the equation:

$$CFcombine = CF1 + CF2(1 - CF1)$$

The calculation is carried out in stages until a final value is obtained which is used as a basis for classifying poverty levels.

3. Results and Discussion

3.1. Result

The research results were obtained through processing a socioeconomic indicator dataset using the Certainty Factor method to determine the level of poverty in the community. The dataset used consists of several key variables, namely per capita expenditure, the Human Development Index (HDI), access to adequate sanitation, access to adequate drinking water, the open unemployment rate, and Regional Gross Domestic Product (GDP). These variables were chosen because they are related to the condition of community welfare and are able to describe the poverty level of a region more comprehensively.

The initial stage is data preprocessing. This stage checks for missing data, inconsistencies, and data with different formats. After the preprocessing process is complete, the next stage is transforming the numerical data into categorical data. This transformation is performed through a discretization process to simplify the representation of data as symptoms in an expert system. The per capita expenditure variable was categorized as low, medium, and high. The sanitation variable was categorized as good and poor, while the HDI variable was categorized as low, medium, and high. Data transformation was performed to facilitate the expert system's inference process using knowledge-based rules.

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Based on the data transformation results, it was discovered that each region has a different combination of socioeconomic indicators. This situation indicates that determining poverty levels cannot be based on a single indicator alone but must consider the relationship between several indicators simultaneously. Therefore, the Factor Certainty method is used to calculate the level of confidence in the poverty category based on the combination of indicators in a region. This study uses a calculation example using data from a region with low expenditure, moderate HDI, and poor sanitation. Each indicator is assigned a confidence value as follows: low expenditure is 0.7, moderate HDI is 0.6, and poor sanitation is 0.6. The calculation process is performed using a step-by-step combination of Factor Certainty formulas.

The first stage involves a combination of low expenditure indicators and medium HDI using the equation:

$$CF1 = 0{,}7 + 0{,}6\ (1 - 0{,}7)$$

Based on the calculation results, the CF1 value was obtained as 0.88. The CF1 result was then combined with the poor sanitation indicator using the following equation:

$$CF2 = 0{,}88 + 0{,}6\ (1 - 0{,}88)$$

The calculation results show a final Certainty Factor value of 0.952. This value indicates a high level of confidence in the poverty category. The closer the value is to 1, the higher the system's confidence in the resulting classification results. The research results show that the Factor Certainty method is capable of combining several socioeconomic indicators into a single confidence value for poverty categories. Thus, the system not only produces a final classification but also provides a level of confidence in the resulting decision. This demonstrates that the Factor Certainty method can be used as an approach to assist in classifying poverty levels in a more objective and measurable manner.

3.2. Discussion

Based on the research results, the Certainty Factor method is considered capable of providing a more flexible approach to handling socioeconomic data containing pollution. Each indicator used in the system contributes to the final confidence value, so that decisions are not solely dependent on a single variable. The simultaneous use of multiple indicators demonstrates that poverty is a multidimensional issue. For example, an area with low expenditure is not necessarily classified as poor if it still has good levels of education, sanitation, and health. Conversely, areas with poor sanitation can have a higher level of well-being if supported by adequate economic conditions. Therefore, the Certainty Factor method is considered appropriate because it can accommodate the relationships between indicators in the classification process.

Furthermore, the expert system developed can also facilitate a more consistent decision-making process. The system operates based on predetermined rules in the knowledge base, resulting in more structured decisions. This can help reduce the subjectivity that typically occurs in manual poverty assessments. The research results also show that transforming numerical data into categorical data impacts the expert system's inference process. Categorical data facilitates the formation of IF-THEN rules, simplifying the classification process. However, the data transformation process can also result in a loss of detailed information from the original numerical data.

In this study, the Certainty Factor values were determined based on the level of influence of each indicator on the poverty category. The determination of these values still relies on assumptions and expert knowledge, potentially resulting in differences in results across implementations. Therefore, further development is needed to ensure a more objective process for determining the Certainty Factor weights. Overall, the Certainty Factor method can be used as an approach in the poverty assessment system. This method can facilitate a more objective, transparent, and systematic classification process, allowing the results to be used as considerations in poverty alleviation policymaking.

However, this study still has several limitations. The dataset used is limited to a few socioeconomic indicators, thus not fully reflecting the overall welfare of the community. Furthermore, this study has not yet conducted comparisons with other classification methods such as Naive Bayes, Decision Tree, or Random Forest. Therefore, future research is recommended to use a larger dataset and include other variables related to the level of community welfare. In addition, further research can also combine the Factor

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Certainty method with machine learning algorithms so that the classification results are more accurate and adaptive to changes in the community's socio-economic data.

4. Conclusion

Based on the research findings, it can be concluded that the Certainty Factor method can be applied to an expert system to assist in assessing poverty levels more objectively and systematically. The system utilized several socioeconomic indicators, such as per capita expenditure, the Human Development Index (HDI), and access to sanitation, to determine the confidence level for a region's poverty classification. The results showed that the Certified Factor method can provide clarity in the decision-making process by combining several indicators to produce a final confidence value. The resulting Certainty Factor value provides information on the level of certainty of the classification results, resulting in more informative decisions than conventional classification processes.

Furthermore, the use of an expert system in this study facilitated a more consistent poverty classification process because the system operates based on predetermined rules and a knowledge base. This reduced subjectivity in the poverty assessment process, resulting in more structured and transparent results. Based on the test results, the combination of low expenditure, moderate HDI, and poor sanitation indicators yielded a Certainty Factor value of 0.952, indicating a high level of confidence in the poverty classification. These results demonstrate that the Certainty Factor method can be used to process several socioeconomic indicators into more measurable classification decisions.

In general, the developed system has the potential to be used as a tool in socioeconomic analysis and social assistance prioritization. However, this study still has several limitations, particularly in the number of indicators used and the assumption-based Certainty Factor weighting process. Therefore, future research is recommended to use a larger dataset, add other socioeconomic variables, and combine the Certainty Factor method with machine learning algorithms to achieve more accurate poverty classification results and adapt to changing community conditions.

Declaration

AI Statement

The authors declare that generative AI tools were used solely to assist with language editing and grammatical improvement. All research ideas, analyses, interpretations, and conclusions are the authors' own. The authors take full responsibility for the content of this manuscript.

Author contribution

Riva Ariefta: Original Draft, Writing
Aulia Putri Zahro: Editing
Heny Pratiwi: Supervision
Muhammad Irsyad: Reviewing

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Additional information

No additional information is available.

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