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A Content-Based Filtering Approach for Matching Village Potentials with Community Service Programs

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ABSTRACT

Village development through the development of village potential is carried out by universities in the form of community service. With the community service program, it is expected to help villages in village development so that they can become independent villages. However, in its implementation, the designed assistance programs are not specific and not aligned with the needs and potential of the village. As a result, the assistance provided is less effective and having minimal impact on village development. One of the causes is the unavailability of data on village potential and problems systematically and structured. Based on these problems, a recommendation system is needed that is able to provide assistance program proposals that are in accordance with the potential and problems of the village specifically and relevantly. This research uses Content-Based Filtering which provides recommendations based on the similarity of input data content with available historical data. The purpose of this research is to make the planning and implementation process of village assistance programs more efficient, effective, and on target. The results of the research are that the Content-Based Filtering method has proven effective in providing recommendations that are appropriate for mapping village potential and village assistance programs.

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1. INTRODUCTION

A village is a legal community unit that has territorial boundaries and is authorized to regulate and manage government affairs, and local community interests by community initiatives, original rights, and/or rights recognized and respected in the government system of the Unitary State of the Republic of Indonesia based on Ministerial Regulation (Permen) number 2 of 2016. Villages as centers of government services to the community at the basic level are the main priority of government development [1]. Village development in Indonesia has become a national development agenda prioritized along with enacting the Village Law in 2014 [2]. To realize a prosperous village community by utilizing all its potential and resources, village development needs to be planned and sustainable by the village government and community [3], or through university assistance. In the context of village typology, the developing village index groups villages into five statuses, namely very underdeveloped villages, underdeveloped villages, developing villages, advanced villages; and independent villages. Meanwhile, the measurement of village development uses the Village Development Index (IPD) [4].

Village potential is a social, economic, and ecological resource found in the village, which can be developed to improve the welfare of the village community. However, sometimes, the potential of this village is not realized because the village community has not been able to optimize the existing potential with all the elements it has [5]. This is also caused by the lack of knowledge on how to develop and utilize natural resources in the village, as well as managing human resources that can improve the standard of living of its people [6]. Each village has its potential that is different from that other villages. The development of village potential aims to encourage village independence or make it an independent village. This is done by strengthening institutions and empowering the community.

The government is currently encouraging village development. This can be seen from the government's ideals regarding villages, namely building from the village and below for economic equality and poverty alleviation. In addition to the government, village development through the development of village potential is also carried out by universities as one of the implementations of the Tri Dharma of Higher Education, namely community service. One of the universities that carries out community service by targeting villages is the Bali State Polytechnic (PNB). The community service program to the village is carried out through collaboration between lecturers and students, such as several PNB flagship programs, namely community service to the village community, institutional service, and Community Empowerment Program Real Work Lectures (KKN-PPM). he community service program to villages or village campuses is a program of transferring knowledge and technology and disseminating university innovations to the community, especially villages. The idea of the village campus program was born from the large availability of research results, innovations, and expertise in universities. On the other hand, many conditions in village communities still require a touch of practical science and technology [7]. With a community service program by universities, it is hoped that it can help villages in village development so that they can become independent villages. However, in its implementation, the designed mentoring program was less specific and not based on the needs or conditions and actual potential of each village. This resulted in the mentoring provided being less effective and having minimal impact on village development. One of the leading causes is the unavailability of systematic and structured data on village potential and problems, so universities must conduct manual surveys in the field before determining the correct form of assistance. This process certainly requires a lot of time and resources. In addition, survey data may not reflect actual conditions, as village communities have been unable to comprehensively convey problems and potential.

Based on these problems, a recommendation system is needed to provide assistance program proposals that are by the potential and problems of each village specifically and relevantly. Recommendation systems are widely applied in various fields to help determine choices from the many available options [8]. A recommendation system is a form of artificial intelligence [9], and machine learning [10], that filters information and helps users to choose appropriate targets from a large amount of information that can be obtained online [11]. The benefits felt from the recommendation system can make it easier for users to find and recommend appropriate information, especially with a lot of information. Recommendation systems continue to develop over time. The main approaches often used in recommendation systems are Content-Based Filtering (CBF), Collaborative Filtering (CF), and Hybrid Filtering (HBF) [12]. This research uses content-based filtering (CBF) because it provides recommendations based on the similarity of content or attributes of input data with historical data that is already available. The Content-Based Filtering method filters based on the contents of an object and measures similarity using Cosine Similarity [10]. The main advantage of content-based filtering is that it does not rely on ratings or feedback from other users as collaborative filtering does, so it is suitable for village data that does not have an explicit assessment system but only contains descriptions of potential problems and aid programs that have been implemented. In addition, this method can handle data in text form through a feature extraction process such as TF-IDF (Term Frequency-Inverse Document Frequency), which allows for practical analysis of similarities between text-based content. In this context, each village can be modeled based on a description of its potential and problems, then matched with historical data using cosine similarity to produce recommendations for the most relevant aid programs. sing content-based filtering with the TF-IDF and cosine similarity approaches is considered efficient and adaptive, and it can provide recommendations that can be logically accounted for because they are based on clear content characteristics. The content-based filtering method has been widely used in various research fields, including culinary, tourism, academic, and agricultural fields to provide recommendations for cafes or restaurants [13], [14], culinary choices [15], MSME product ideas [16], vape liquid [17], films [18], [19], [20], podcasts [21], picnic spots [22], camping equipment [23], homestays [24], tour guides and tourist destinations [25], books in the library [26], appropriate literature [27], student elective courses [28], training programs [8], jobs in vocational education [29,] to plant disease identification [30].

The novelty of this research lies in applying the content-based filtering method for a recommendation system for village assistance programs based on the potential and actual problems of the village. Unlike previous studies that generally focus on recommendation systems based on individual user needs (user-centered), such as in e-commerce or education, this research targets the institutional context. It is based on administrative areas, namely villages. Previous studies also tend to rely on collaborative filtering or hybrid approaches that require historical data in the form of user feedback (ratings), which are not available in the context of village assistance programs. The system developed in this research also presents a digital village potential mapping approach, thus supporting more focused, efficient, and accountable community service governance. Therefore, this research makes a real contribution to developing a content-based recommendation information system for the village community service and empowerment sector, especially in the vocational college environment.

With this recommendation system, it is hoped that village assistance programs' planning and implementation process will be more efficient, effective, and on target. This system helps accelerate the process of identifying village needs and strengthens transparency, accountability, and evaluation of the programs being run. In the long term, the development of this system contributes to improving the quality of community service programs and supports the realization of independent and prosperous villages.

2. RESEARCH METHOD

In general, developing a recommendation system for linking and matching village potential or problems with community service programs has several stages. The stages in the research can be seen in Figure 1. This research begins with data input in the form of village potential, problems, and assistance programs owned by universities. This research uses data from 90 villages spread across all regencies/cities in Bali Province. Data were collected from reports of the KKN-PPM, village development, and community service institutional programs of the Bali State Polytechnic from 2020–2024. All data are historical and collected directly from internal sources of the institution, not from the public data scraping process. Data from 90 villages used in this research show a variety of potentials and problems, ranging from agriculture, tourism, and crafts to infrastructure issues. However, no explicit data balancing was carried out because the content-based recommendation system does not rely on label distribution as in the supervised learning method. This content diversity is a challenge and a major strength in producing relevant and contextual recommendations for each village. The data is then processed using the content-based filtering method. The first stage in the content-based filtering method is preprocessing text for input data, calculating TF (Term Frequency), calculating IDF (Inverse Document Frequency), calculating TF-IDF (Term Frequency - Inverse Document Frequency, Vector Representation, and calculating Cosine Similarity. In text preprocessing, tokenization, Lowercasing, Stop Words Removal, and Stemming are carried out. Then, the TF-IDF approach analyzes the importance of terms in the data set [24] and gives more appropriate weight to relevant but not too familiar words, resulting in more accurate recommendations compared to other methods [17]. The vector representation is to create a vector in the form of an array. After that, the calculation of Cosine Similarity for item matching

[15]. The highest cosine similarity value will be considered as the recommendation result. Furthermore, a recommendation system that implements the content-based filtering method is developed. The recommendation system was developed in PHP with an API structure and tested using User Acceptance Testing (UAT) involving 15 lecturers from Politeknik Negeri Bali. The built API will be used by the services that require it. The last stage is testing using User Acceptance Testing (UAT). User Acceptance Testing (UAT) is a verification process to ensure that the solution developed in the system is by user needs. This differs from system testing, which aims for the software not to crash and by user request documents. UAT focuses on ensuring that the solution provided will work effectively for end users, namely testing whether users accept the solution provided in the system [31]. This research involved six main stages as illustrated in Figure 1.

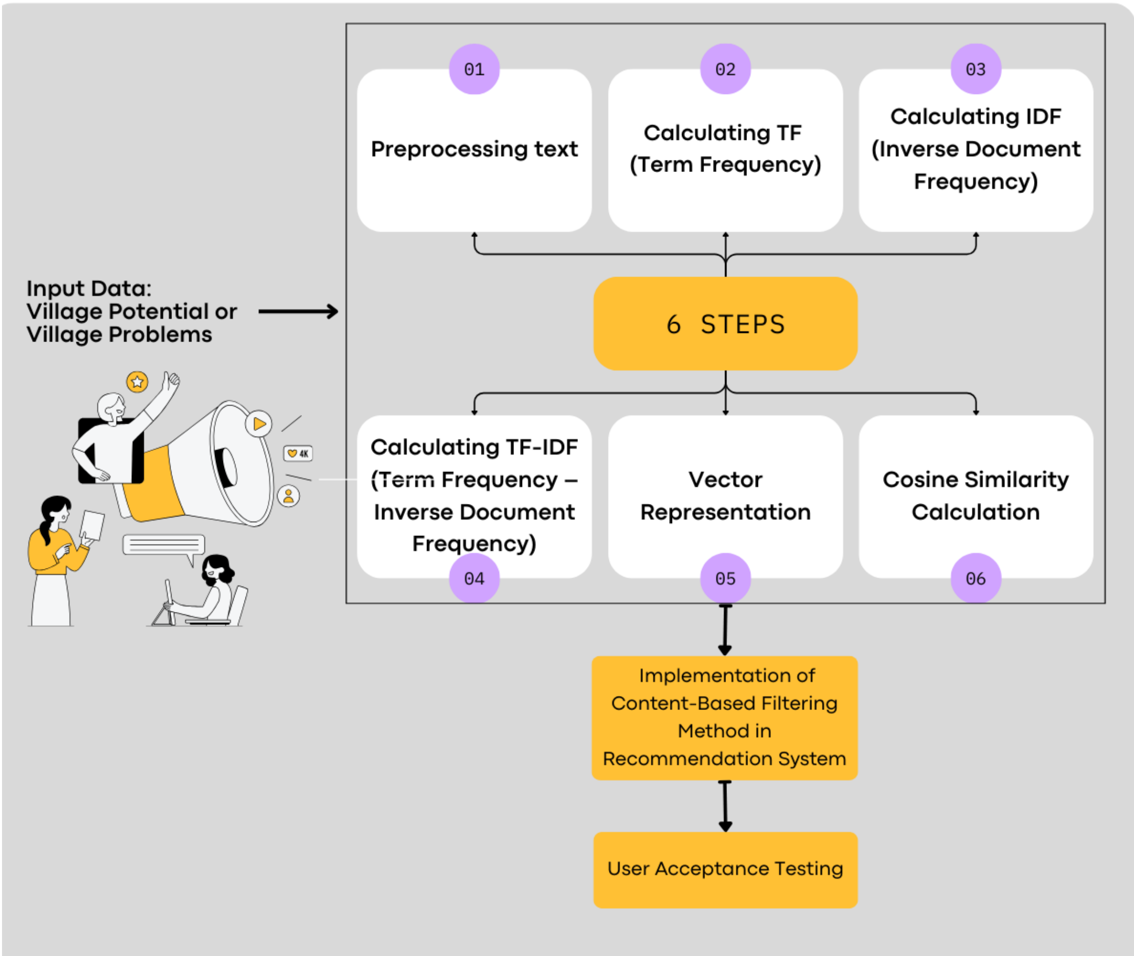

Figure 1. Research Flow of the Content-Based Filtering Recommendation System

3. RESULTS AND DISCUSSION

3.1. Simulation of Content-based Filtering Method Calculation

Before conducting the calculation simulation, a description of the input data on potential problems and historical data containing potential problems and assistance programs will be carried out:

1. Input potential or problems: produk indah agrowisata.
2. Historical data:

Table 1. History data

Data	History data 1	History data 2	History data 3
Potential	alamnya indah	budaya masyarakatnya kuat	komoditas kebun jeruk dan jalur trekking motocross
Problems	infrastruktur untuk agrowisata	kurangnya fasilitas pendukung kelistrikan	pelatihan pengemasan produk
Assistance Program	melakukan pembangunan infrastruktur untuk agrowisata	pemasangan instalasi lampu	memberikan pengetahuan cara mengemas produk

3. Preprocessing Text :
   a. Tokenization: this process transforms the text into several small units. The resulting input is “produk”, ”indah”, ”agrowisata”.
   b. Lowercasing: This process changes text or sentences into lowercase letters (lowercase letters). When the input is already in lowercase, it will remain “produk”, “indah”, “agrowisata”.
   c. Stop Words Removal: at this stage, less important conjunctions such as "and, or, from, which, etc." will be removed. If the input does not have a conjunction, it will remain “produk”, “indah”, “agrowisata”.
   d. Stemming: this process will change text into basic words. For example, “memiliki” will be changed to “milik”, “berlari” will be changed to “lari”, “mempunyai” will be changed to “punya”, etc. In the input, all words are already in basic word form, so it will remain “produk”, “indah”, “agrowisata”.
4. TF (Term Frequency) Calculation
   At this stage, the occurrence of words in the given input will be calculated. For example, given an input example in the form of " produk indah agrowisata indah" then the word "indah" will be counted only 1 time. Still, the weight given is 2 because the word "indah" appears 2 times in the input example. In the given input, all words only appear 1 time, so:
   TF("produk", ["produk", "indah", "agrowisata"]) = 1 (appears 1 time)
   TF("indah", ["produk", "indah", "agrowisata"]) = 1 (appears 1 time)
   TF("agrowisata", ["produk", "indah", "agrowisata"]) = 1 (appears 1 time)
5. Calculating DF (Document Frequency)
   At this stage, the occurrence of words in the input given to the existing historical data will be calculated so:
   DF("produk") = 1 (contained in potential + problems of historical data 3)
   DF("indah") = 1 (contained in potential + problems of historical data 1)
   DF("agrowisata") = 1 (contained in potential + problems of historical data 1)
6. Calculating IDF (Inverse Document Frequency)
   At this stage, a measurement will be made of how important the term (word) is in the historical data. The IDF formula is:
   IDF(term) = log(Total Historical Data / (DF + 1)). Then:
   IDF("produk") = log(3 / (1 + 1)) = 0.176
   IDF("indah") = log(3 / (1 + 1)) = 0.176
   IDF("agrowisata") = log(3 / (1 + 1)) = 0.176
7. Calculating TF-IDF (Term Frequency – Inverse Document Frequency)
   At this stage, 2 components will be combined, namely TF and IDF. TF will measure how often the term appears while IDF will measure how important the term is in historical data. The TF-IDF formula is:
   TF-IDF(term) = TF(term) * IDF(term). Then:
   TF-IDF("produk") = TF("produk") * IDF("produk") = 1 * 0.176 = 0.176
   TF-IDF("indah") = TF("indah") * IDF("indah") = 1 * 0.176 = 0.176
   TF-IDF("agrowisata") = TF("agrowisata") * IDF("agrowisata") = 1 * 0.176 = 0.176
8. Vector Representation

At this stage, the vector representation will be done in the form as an array. This stage will make the array represent each attribute. Each attribute is input and historical data. So, the TF-IDF vector representation will be :
TF-IDF Input Vector: [0.176, 0.176, 0.176]
TF-IDF Vector Historical Data 1 (Potential + Problems): [0, 0.176, 0.176]
TF-IDF Vector Historical Data 2 (Potential + Problems): [0, 0, 0]
TF-IDF Vector Historical Data 3 (Potential + Problems): [0.176, 0, 0]

9. Cosine Similarity Calculation
At this stage, the similarity between 2 vectors will be calculated. The cosine similarity value ranges from -1 to 1 where a value of -1 indicates that 2 vectors are opposite, a value of 0 indicates that 2 vectors have no relationship, and a value of 1 indicates that 2 vectors have the same value. The closer the cosine similarity value is to 1, the higher the similarity between the 2 vectors. The cosine similarity formula is:
cosine_similarity(A, B) = (A . B) / (||A|| * ||B||)
where:
(A . B) is the result of the dot product multiplication between vectors A and B.
||A|| is the length (norm) of vector A, which is calculated as the square root of the sum of the squares of the elements of vector A.
||B|| is the length (norm) of vector B, which is calculated as the square root of the sum of the squares of the elements of vector B.
The cosine similarity calculation is performed between the input vector and the history data vector 1:
   - Dot Product Input with History Data 1 = (0.176 * 0) + (0.176 * 0.176) + (0.176 * 0.176) = 0.061.
   - Length (Norm) of Input Vector = sqrt((0.176^2) + (0.176^2) + (0.176^2)) = 0.304.
   - Length (Norm) of History Data Vector 1 = sqrt((0^2) + (0.176^2) + (0.176^2)) = 0.248.
   - Input Cosine Similarity Value with Historical Data 1 = 0.061 / (0.304 * 0.248) = **0.809.**

The cosine similarity calculation is carried out between the input vector and the historical data vector 2:
   - Dot Product Input with Historical Data 2 = (0.176 * 0) + (0.176 * 0) + (0.176 * 0) = 0.
   - Length (Norm) of Input Vector = sqrt((0.176^2) + (0.176^2) + (0.176^2)) = 0.304.
   - Length (Norm) of Historical Data Vector 2 = sqrt((0^2) + (0^2) + (0^2)) = 0.
   - Cosine Similarity Value of Input with Historical Data 2 = 0 / (0.304 * 0) = **0.**

The cosine similarity calculation is carried out between the input vector and the historical data vector 3:
   - Dot Product Input with Historical Data 3 = (0.176 * 0.176) + (0.176 * 0) + (0.176 * 0) = 0.03.
   - Length (Norm) of Input Vector = sqrt((0.176^2) + (0.176^2) + (0.176^2)) = 0.304.
   - Length (Norm) of Historical Data Vector 3 = sqrt((0.176 ^2) + (0^2) + (0^2)) = 0.176.
   - Cosine Similarity Input Value with Historical Data 3 = 0.03 / (0.304 * 0.176) = **0.56.**

Table 2. Accuracy Results with Cosine Similarity

Content-Based Filtering	Historical Data 1	Historical Data 2	Historical Data 3
Nilai Cosine Similarity	0.809	0	0.56

Table 2 shows the accuracy results with Cosine Similarity. It can be concluded from the accuracy results of table 2 above that the cosine similarity value of the input data in the form of "beautiful agrotourism products" with 3 historical data, historical data 1 provides the best cosine similarity value of 0.809 or around 80%. This is appropriate because the words "indah" and "agrowisata" are in historical data 1, while the word "product" is in historical data 3 which has a cosine similarity value of 0.56 or around 56%. While in historical data 2 has a cosine similarity value of 0 or no inputted words appear in historical data 2. Therefore, historical data 1 becomes a priority recommendation that has potential and problems: " alamnya indah infrastruktur untuk agrowisata" and assistance programs: " melakukan pembangunan infrastruktur untuk agrowisata".

In addition to evaluation based on cosine similarity, the system's performance was assessed using precision, recall, and F1-score through a straightforward validation scenario. Ten input cases representing different villages were manually tested with the involvement of external evaluators, each serving as a representative of local village authorities. These evaluators evaluated the relevance of the programs recommended by the system. The results of this evaluation are summarized in Table 3.

Table 3. System Performance Evaluation Based on Precision, Recall, and F1-Score

Village Input	Number of Recommendations	Relevant (TP)	Irrelevant (FP)	That Should Appear but Did Not (FN)	Precision	Recall	F1-Score
Sidemen Village	5	3	2	1	0.6	0.75	0.6667
Kemenuh Village	4	2	2	2	0.5	0.5	0.5
Bongkasa Pertiwi Village	5	4	1	1	0.8	0.8	0.8
Menanga Village	5	3	2	2	0.6	0.6	0.6
Bonyoh Village	5	4	1	0	0.8	1.0	0.8889
Sukawati Village	5	3	2	1	0.6	0.75	0.6667
GuwangVillage	5	4	1	2	0.8	0.67	0.7273
Manduang Village	5	2	3	1	0.4	0.67	0.5
Tista Village	5	3	2	0	0.6	1.0	0.75
Perean Village	5	4	1	1	0.8	0.8	0.8

The average evaluation results from ten simulations indicated a precision of 0.65, a recall of 0.75, and an F1-score of 0.70. These values fall within the category of moderately good performance for a content-based recommendation system, particularly considering the complexity of village data and the manual nature of the validation process. The range of values across the simulations also demonstrates consistent performance, with precision ranging from 0.40 to 0.80, recall from 0.50 to 1.00, and F1-score from 0.50 to 0.89. This evaluation suggests that the system can generate recommendations that are both relevant and contextual to the specific needs of the villages.

3.2. Implementation of Content-Based Filtering Method in Link and Match Recommendation System Village potential with community service activities

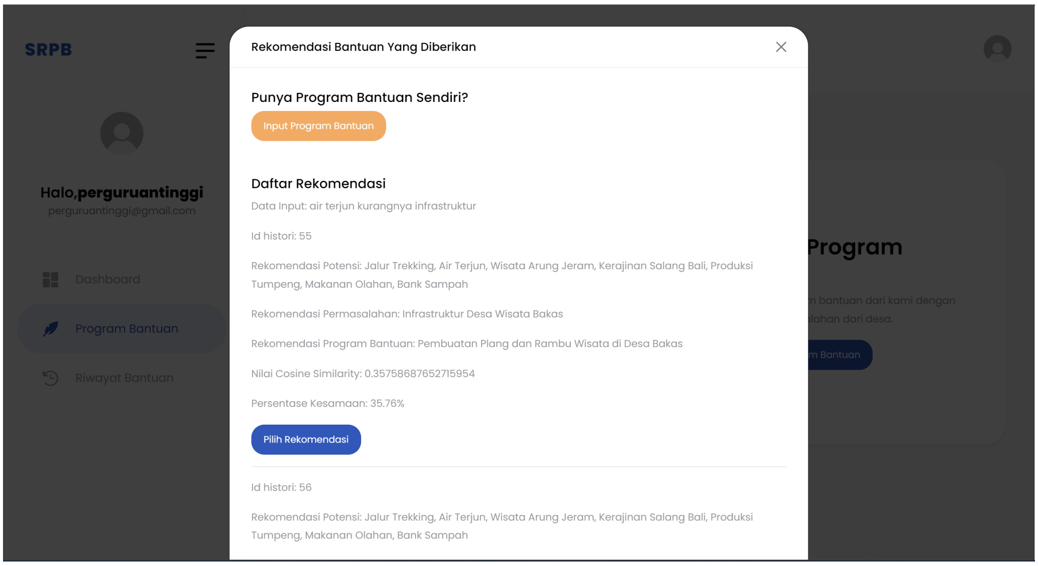

Figure 2. Implementation of the Content-Based Filtering Method

The Results of the Implementation of the Content-Based Filtering Method in the Link and Match Recommendation System The potential of villages with community service activities can be seen in Figure 2. The interface demonstrates real-time calculation of cosine similarity and assistance suggestions. The use of the content-based filtering method in the recommendation system is on the assistance program page. In the display above, the cosine similarity value is displayed as 0.357 with the input data " air terjun kurangnya infrastruktur" and several recommendations are displayed. To get recommendations, the input data will be processed first. Namely, text preprocessing (tokenization, lowercasing, removal of stop words, stemming), and then the TF (Term Frequency) calculation will be carried out. The DF (Document Frequency) calculation will be carried out, the IDF (Inverse Document Frequency) calculation will be carried out, and the TF-IDF (Term Frequency - Inverse Document Frequency) calculation will be carried out. The vector representation will be carried out, and the cosine similarity value will be obtained. This cosine similarity value will determine the recommendations given; the greater the value, the greater the similarity between the input data and the historical data in the database.

3.3. User Acceptance Testing (UAT)

User Acceptance Testing functions to determine whether the user has accepted the system created or not. The assistance recommendation feature will be tested in this UAT, where the university will be the user who will use this feature. Therefore, lecturers at the Politeknik Negeri Bali will be involved in conducting testing using a questionnaire.

Table 3. User Acceptance Testing Results

No.	Question	Frequency Response				
		SS	S	KS	TS	STS
1	The user interface display on the assistance program recommendation feature is easy to understand	7	7	1	0	0
2	The assistance program recommendation feature works well	7	8	0	0	0
3	The recommendations given by the system are by potential or similar problems	5	10	0	0	0
4	The recommendations can be used as a reference for assistance programs	8	7	0	0	0
	Total	27	32	1	0	0

After obtaining the total frequency of responses from each scale, the total will then be calculated with its weight using the formula:

Total of response frequencies with SS scale x SS weight = 27 x 5 = 135
Total of response frequencies with S scale x S weight = 32 x 4 = 128
Total of response frequencies with KS scale x KS weight = 1 x 3 = 3
Total of response frequencies with TS scale x TS weight = 0 x 2 = 0
Total of response frequencies with STS scale x STS weight = 0 x 1 = 0

Total = 209

$$\frac{266}{300} x100\% = 88{,}6\%$$

The User Acceptance Testing involved 15 lecturers who were representatives of the community service program proposers. However, this testing was limited to evaluating aspects of ease of use and perceived relevance of the recommendations. Based on the results of User Acceptance Testing, where 15 respondents were lecturers at the Politeknik Negeri Bali who would later act as university users in the system, the test results for the assistance program recommendation feature were 88.6%, it can be concluded that the assistance program recommendation feature in the university service on the user interface display is easy to understand. The recommendations given are by the potential problems of the village.

The current validation was limited to 15 respondents from the same institution (Politeknik Negeri Bali). For broader generalizability, future work will include external validation involving different higher education institutions and a more diverse set of villages with varying characteristics (e.g., remote rural, semi-urban, coastal). This would help assess the adaptability and robustness of the recommendation system across different contexts.

Despite the benefits of the content-based filtering approach, the system may face limitations in recommending relevant programs for new villages with little or no historical data (cold start problem). Future research can consider incorporating clustering techniques to group similar villages based on metadata (e.g., geographic region, economic profile, or existing infrastructure) to address this. These clusters can serve as surrogate historical data for new villages. Metadata enrichment, such as socio-demographic information and environmental characteristics, may also help improve recommendation quality under cold start conditions. In addition, metadata enrichment through qualitative surveys and government datasets may also improve recommendation relevance. In addition, future research is recommended to compare the performance of Content-Based Filtering, Collaborative Filtering, and Hybrid Filtering approaches to evaluate their effectiveness and accuracy across different village data conditions.

4. CONCLUSION

This research demonstrates that a recommendation system based on Content-Based Filtering can effectively suggest village assistance programs based on local potential and existing issues. This method performs well in the context of descriptive data and does not require explicit user feedback. However, the system still has limitations regarding performance evaluation and user acceptance in real-world settings, which should be addressed through further testing and method comparison. This system is expected to serve as an initial step toward digitizing the community service process in a manner that is more accurate, efficient, and contextually relevant.

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