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The Application Of Fuzzy Analytic Hierarchy Process (FAHP) In Agribusiness Strategic Decision Making : Narrative Review

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ABSTRACT
Strategic decision-making in the agriculture and agribusiness sectors generally involves many criteria that are qualitative, subjective, and full of uncertainty. This condition encourages the use of a multi-criteria decision-making method based on fuzzy logic, one of which is the Fuzzy Analytic Hierarchy Process (FAHP). However, the literature review related to the use of FAHP in the scope of agriculture and agribusiness is still very limited. This article aims to review the narrative use of FAHP in strategic decision formulation in the field of agriculture and agribusiness, focusing on the scope of application, methodological usage patterns, and limitations that still arise in existing studies. The method used is a review of the narrative literature on national and international journal articles using the FAHP method and published in the range of 2015-2025. Articles must be related to agriculture or agribusiness management. A total of 14 relevant articles were obtained from scientific databases and open online sources such as Google Scholar, sciencedirect and Semantic Scholar.The results of the review show that FAHP has been widely used in various strategic decisions, such as the selection of superior commodities, the suitability of production sites assessment, the evaluation of technologies and production systems, and risk mitigation in the supply chain and marketing. However, most studies still place FAHP as a weighting and ranking tool for criteria or alternatives, with relatively limited discussion of strategic implications. This article concludes that FAHP has great potential to be further developed within a more comprehensive strategic decision-making framework, especially through integration with sustainability approaches, real-time data, and other analytical methods.

KEYWORDS: Fuzzy AHP, Strategic decision-making, Agribusiness, Narrative review, MCDM

1. INTRODUCTION

The agricultural sector is a potential economic sector that still faces many problems in the development process. Production sustainability, farming efficiency and improving farmers' welfare are still the main problems that have not been resolved properly. Many studies have taken a strategic approach to address these problems. Because problems in the agricultural sector require solutions that are able to have an impact for a long period of time and are systemic, so it is not appropriate to be seen as a purely tactical or operational problem (Papadakis and Barwise, 1997). Through this approach, it is hoped that strategic decisions can be obtained and can be applied as a real solution in the agricultural sector, especially agribusiness.

However, in a strategic approach, the development of the agricultural sector requires the formulation of a comprehensive and holistic strategy, as it involves various technical, economic, social, and environmental dimensions simultaneously. This complexity is further exacerbated by the high uncertainty of climate change, volatility in commodity prices, limited market and technological access, and the heterogeneity of the socio-economic conditions of farmers (Gheddar, 2023; Grigorieva *et al.*, 2023; Raji & Njoku, 2024). This condition causes the strategic decision-making process in the agricultural sector to be not only complex, but also fraught with ambiguity and risks, especially in determining priorities and selecting the most appropriate alternative strategies to implement. To get around this condition, a decision-making method is needed that is able to consider various criteria in a structured and evidence-based manner.

Multi-Criteria Decision Making (MCDM) method offers a systematic framework for dealing with decision-making problems in a complex environment with many assessment criteria. One of the most widely used methods is Analytic Hierarchy Process (AHP), which was introduced by Saaty in 1980. AHP is popular for the simplicity of it's hierarchical structure and it's ability to capture decision-maker's preferences. However, AHP has some fundamental weaknesses such as its inability to handle assessment uncertainty, high subjectivity,

potential inconsistencies in the comparison matrix, and reliance on assessment scales Crisp 1–9 (precise numerical judgements) (Alharairi *et al*., 2025; Cremades & Ponsich, 2024; Harahap *et al*., 2022; Zhang, 2025). These limitations make AHP less than optimal to represent vague or ambiguous perceptions and assessments, as often found in the context of strategic planning in the agricultural sector.

In order to overcome these problems, Fuzzy Analytic Hierarchy Process (FAHP) is developed by integrating set theory fuzzy into the classical AHP, so that preference assessments can be represented in the form of fuzzy numbers are more flexible and realistic (Van Laarhoven & Pedrycz, 1983; Yu & Liu, 2021). This approach has been shown to be effective in reducing uncertainty, suppressing subjectivity, and improving the quality of decision-making (Alyamani & Long, 2020; Peng *et al.*, 2021).

In recent years, FAHP has been widely used as a multi-criteria decision-making method capable of handling uncertainty and linguistic assessment. Various studies have reported on performance Fuzzy AHP in many sectors, such as in human resource management (Salehzadeh & Ziaeian, 2024), engineering (Varshney *et al*., 2024), construction (Getawa Ayalew *et al*., 2024), service industry (Bakir & Atalik, 2021), and agriculture (Atlı, 2024; Martins *et al*., 2023). The application of this method in the agriculture and agribusiness sectors shows considerable potential to support strategy formulation, especially related to product selection, location, technology, supply chain, institutional, to risk and sustainability. However, a literature review that conducts an integrative synthesis of FAHP application patterns in the strategic scope, especially in the field of agribusiness, is considered to be still unavailable.

In this regard, this literature review is compiled to obtain extensive information about the FAHP method, be it regarding usage patterns, roles or positions in strategic decision-making, as well as the advantages of this method in the context of strategic decision-making. In addition, this literature review also seeks to highlight areas that require further research and map future research opportunities, especially based on the FAHP method.

2. MATERIALS AND METHODS

This study uses a narrative review approach to examine the use of the Fuzzy Analytic Hierarchy Process (FAHP) method in strategic decision-making in the agriculture and agribusiness sectors. According to Green *et al*. (2006), a narrative review is a comprehensive but non-systematic review that seeks to synthesize various previous studies. Narrative review was chosen because it was methodologically flexible (does not require following a specific pattern) and has a broader scope of discussion. In addition, the principle of subjectivity in narrative review allows reviewers to interpret and provide criticism of literature according to their understanding. (Green *et al*., 2006; Sukhera, 2022).

In the preparation of this narrative literature review, several stages are carried out referring to the opinion of Green *et al*. (2006), namely preparation includes determining the topic and research questions to be answered. Then determine the base/source of literature used, literature criteria, year range and literature keywords. The next stage is to summarize, criticize and synthesize findings from various literature by highlighting the similarities and differences that exist. The last stage is to reconnect the findings and synthesis with the initial purpose of the research.

The literature reviewed consists of national and international journal articles relevant to FAHP topics and decision-making in the field of agriculture and agribusiness, published within the last ten years or in the range of 2015-2025. The literature search process is carried out through scientific databases and open online sources such as Google Scholar, sciencedirect and Semantic Scholar. Meanwhile, the keywords used were Fuzzy AHP, FAHP, agricultural decision making, agribusiness strategy, selection of superior commodities, land suitability, technology evaluation, and marketing and supply chain risk.

The selected articles are studies that explicitly use FAHP as the main method or part of a multi-criteria decision-making framework in commodity selection, production site determination, evaluation of production technologies and systems, as well as supply chain and marketing strategies. The collected literature was then analyzed qualitatively by grouping studies based on the scope of the strategic decision being studied. The analysis focused on the usage patterns and role of FAHP in the decision-making process as well as the methodological position of FAHP in the framework of analysis used.

3. RESULT AND DISCUSSION

3.1. General Overview of FAHP Usage

Strategic decisions have fundamental characteristic differences compared to technical-operational decisions. At the very least, strategic decisions are broader, riskier, have a long-term dimension, are about sustainability and deal with uncertainty (Papadakis & Barwise, 1997; Sit *et al*., 2025). Therefore, in strategic decision-making, the dominance of subjectivity and doubt or uncertainty must be reduced as much as possible.

As described in the introduction, FAHP is present as one of the answers to the fundamental weaknesses of the classical AHP method. Basically, there is no fundamental overhaul of the classic AHP method, only changes are made to the basis of assessment logic through the integration of fuzzy logic. This relatively simple change is able to help the performance of decision-makers by emphasizing ambiguity and subjectivity of assessments.

The results of the literature search related to the use of FAHP in strategic decision-making in the field of agriculture or agribusiness are summarized and displayed in table 1 below.

Table 1. Summary of the literature on the use of FAHP

No	Topics	Research	Method	Results/patterns of FAHP use
1	Selection of leading commodities	Budiarto *et al*. (2019)	FAHP	Superior rice varieties are obtained through expert assessment using FAHP
2	Selection of leading commodities	Adiprasetyo & Cahyadinata (2020)	FAHP, Location Quotient, Differential Shift, Analisis EFE-IFE, Analisis SWOT, AHP	Regional leading commodities are selected using a series of integrated methods. FAHP in this study acts as an alternative ranking of superior commodities after the analysis of LQ and DS.
3	Selection of leading commodities	Resi *et al*. (2024)	FAHP, Location Quotient	The combination of the two methods is able to produce relatively accurate results, especially when the number of assessment criteria is quite large
4	Suitability of agricultural production sites	Pilevar *et al*. (2020), Kilic *et al*. (2022)	FAHP, GIS Analysis	A number of soil characteristics such as topographic conditions, soil texture, soil chemistry and climatological information of the location were assessed using FAHP and the final result was obtained in the form of a soil characteristic suitability rating for commodities such as wheat and maize in Turkey and Iran.
5	Suitability of agricultural production sites	Tashayo *et al*. (2020)	FAHP, GIS Analysis, Geostatistical Analysis	In this study, FAHP was used to assess the ranking of soil characteristics. In addition to GIS analysis, FAHP is also combined with geostatistical analysis to support the validity of assessment results
6	Suitability of agricultural production sites	Rodcha *et al.* (2019)	FAHP, AHP	The results of the comparison between FAHP and classic AHP for the purpose of land suitability assessment show that FAHP provides higher classification accuracy in the context of uncertain preferences of experts.
7	Suitability of agricultural production sites	Shaloo *et al*. (2022)	FAHP, AHP	The use of classical AHP was more (53%) than FAHP (16%) in land suitability evaluation studies
8	Evaluation of Production Technology and Systems	Zhang *et al*. (2020)	FAHP	FAHP is used to assess the various alternative choices of wastewater management technology available so that the technology that suits the location is obtained.
9	Evaluation of Production Technology and Systems	Sharma *et al*. (2025)	Modifikasi FAHP (Fuzzy Extent Analysis (FEA)	In this study, FEA was used to evaluate the impact of various tillage and irrigation methods, especially on several agricultural parameters such as affordability (cost efficiency), production yield, climate resilience and water use level.

10	Evaluation of Production Technology and Systems	Qureshi *et al*. (2022)	FAHP dan AHP	This research is related to the practice *of Climate Smart Agriculture* (CSA) in sustainable agricultural production. FAHP is used as a tool for validating decisions taken with the classical AHP approach
11	Evaluation of Production Technology and Systems	Belaid *et al*. (2024)	FAHP, GIS analysis	This study shows how FAHP can play a role in connecting technological aspects in the spatial and operational framework of agriculture. FAHP is used as a decision-making tool regarding the location of solar panel placement with consideration of the multi-criteria that exist in solar panel technology.
12	Supply Chain Strategy and Marketing	Wahyuningtyas et al. (2021)	FAHP	FAHP is used as a method to weigh several risks that may be faced by actors along the semi-organic rice supply chain. In this study, there is attention to the level of consistency of the assessment (Consistency Ratio), where if the results of the calculation of the consistency level exceed the threshold of 0.100, the weighting must be repeated.
13	Supply Chain Strategy and Marketing	Choirun *et al*. (2024)	Fuzzy Failure Mode and Effects Analysis (Fuzzy FMEA) , Fuzzy Analytic Hierarchy Process (FAHP)	*Fuzzy* FMEA is used for risk mapping and prioritization, while FAHP is used to evaluate and prioritize alternative risk mitigation strategies in the robusta coffee supply chain.
14	Supply Chain Strategy and Marketing	Atlı (2024)	FAHP dan ARAS-F (Fuzzy Additive Ratio ASsesment)	FAHP plays a role in determining the weight of the criteria that are the basis for the selection of sustainable fertilizer suppliers. This research is based on qualitative and quantitative data.
14	Supply Chain Strategy and Marketing	Atli (2025)	FAHP dan fuzzy COPRAS (COmplex PRoportional ASsessment)	FAHP is used in an integrated manner with FCOPRAS in strategic decision-making in the field of marketing, i.e. to determine the right target market.

From the results of the analysis of various studies shown in table 1, it can be concluded that FAHP can accommodate many criteria and maintain consistency through a hierarchical approach, making it suitable for decisions that consider cross-aspects such as technical, economic, social, and environmental. In addition, in the decision-making process, there is a tendency for FAHP to be combined with other methods. The ability to be compatible with a wide range of other methods demonstrates the high flexibility of FAHP (Al-Refaie & Aljundi, 2024; Başaran & Ighagbon, 2024; Demircan & Yetilmezsoy, 2023). This flexibility emphasizes the position of FAHP as an adaptive method in strategic decision-making that is multi-criteria. The use of FAHP as a single method (Budiarto *et al*., 2019; Wahyuningtyas *et al*., 2021; Zhang *et al*., 2020) tend to be found in studies with a more defined and relatively narrow scope of problems. This difference indicates that the complexity of the problem is one of the determining factors in methodological design.

This methodological flexibility is rooted in FATP's ability to manage data complexity, especially in the qualitative realm. Handling qualitative data can be both a challenge and an opportunity in strategic decision-making. As an opportunity, qualitative data, which is generally in the form of linguistic data, is more in line with the way humans assess things (Wu & Xu, 2021), so the possibility of getting the right decision is more open. However, on the other hand, the nature of linguistic data is often vague (*imprecise*), uncertain and requires a mathematical transformation. Related to these challenges, the presence of fuzzy logic in FAHP accommodates the uncertainty and ambiguity of expert preferences (Castelló-Sirvent *et al*., 2022; Kahraman *et al*., 2022). Furthermore, FAHP has proven to be able to handle quantitative and qualitative databases, integrating the two in one framework and operating in a cross-faceted manner (Adiprasetyo & Cahyadinata, 2020; Atli, 2024; Atli, 2025; Belaid *et al*., 2024; Kılıc *et al*., 2022; Pilevar *et al*., 2020; Qureshi *et al*., 2022; Resi *et al*, 2024; Rodcha *et al*., 2019; Sharma *et al*., 2025; Tashayo *et al*., 2020; Zhang *et al*., 2020).

Furthermore, based on the general patterns reflected in the literature reviewed, the FAHP method is widely used to support technical and tactical analysis, especially as a criterion weighting tool. Most researchers have not viewed the area being studied as a strategic aspect of agribusiness management. The researcher only positions it as an ordinary operational technical decision-making process. As in the land suitability evaluation study, most researchers (Kılıc *et al*., 2022; Pilevar *et al*., 2020; Tashayo *et al*., 2020) Just looking for the answer to the question "is this land suitable?" or "unsuitable" for a particular commodity. If the researcher's perspective

changes from technical to strategic, the questions that need to be answered by the researcher will be more complex because the strategic aspect requires broader consideration than the technical aspect. Of course, this is not a shortcoming of the researcher, but purely as a choice of research focus. Nonetheless, this can be a gap for other researchers to conduct studies with a broader, integrated and strategic perspective.

3.2. Application of FAHP in Agribusiness Strategic Decision Making

3.2.1. Application of FAHP in the Selection of Superior Commodities

In the study of the selection of superior commodities, decisions generally involve various criteria that interact with each other, such as agroecological potential, economic feasibility, market demand, production risk, and social and environmental aspects. For this purpose, FAHP plays a role mainly as a ranking tool for alternative ranking of leading commodities (Adiprasetyo & Cahyadinata, 2020; Resi *et al*., 2024). This condition does not reflect the limitations of FAHP as a decision-making method, but rather shows that the potential of FAHP in supporting the assessment of internal-external factors that are subjective and full of uncertainty has not been fully explored. Conceptually, FAHP's excellence in addressing linguistic assessments and the ambiguity of decision-makers' perceptions provides an opportunity to strengthen the analysis of strategic factors, such as SWOT, which have been vulnerable to subjectivity. In general, in existing research practices, the role of FAHP still tends to be limited to the ranking stage of leading commodities, thus opening up the possibility for further research to develop a more integrative use of FAHP in the formulation of agribusiness strategies.

3.2.2. FAHP for Assessment of Suitability of Agricultural Production Sites

The factor of land suitability for agricultural commodity production activities is one of the strategic aspects that must be decided carefully. This is because the suitability of the land will also affect the success of the investment made. Suitable land will facilitate the production process and be able to provide optimal production results. However, the assessment related to this is relatively complex because it must consider many criteria, especially from the biophysical aspect. In addition to involving many biophysical criteria, land suitability assessments are also faced with uncertainty of environmental data as well as differences in experts' perceptions in assessing the level of importance of each criterion. This condition makes the fuzzy-based MCDM approach such as FAHP relevant to be used in the process of evaluating the suitability of agricultural production sites.

From several studies that have been reviewed, it can be understood that the use of FAHP is quite effective and accurate in land use management activities through land suitability assessment for the production of certain commodities (Rodcha *et al*., 2019). Although the results of the Shaloo *et al*. (2022) study show that classical AHP is more widely used in land suitability assessment studies. This difference can be understood because the multi-criteria nature of land suitability evaluation can be approached quantitatively. Criteria regarding soil characteristics, agroclimatological conditions, and land topography can be easily presented in clear quantitative data and easy to assess *crisply*.

In general, these studies show a relatively uniform pattern of use of FAHP, i.e. as a tool to determine the weight of biophysical criteria before GIS-based spatial analysis is carried out (Kılıc *et al*., 2022; Pilevar *et al*., 2020; Tashayo *et al*., 2020). Thus, the role of FAHP in these studies is more of a support for the technical evaluation of land suitability, rather than as a direct determinant of strategic decisions. FAHP functions primarily at the assessment stage of preferences and relative importance between criteria, while final decisions regarding site selection are determined through spatial analysis and land suitability classification. However, most of the applications of FAHP in land suitability assessments are still oriented to technical-biophysical aspects, so the strategic dimensions of agribusiness, such as linkages to market access, environmental sustainability, and regional economic impacts, have not been a major concern and have the potential to be explored in other studies.

3.2.3. Application of FAHP in Technology and Production System Evaluation

The role of technology in supporting agricultural production activities today shows a strengthening direction in line with increasing demands for efficiency, productivity, sustainability, and adaptability to climate change and market dynamics. A wide range of relevant and efficient technologies have been widely introduced. Currently, the decision is no longer about whether to use technology or not, but rather about which technology to adopt. Selecting the right technology adoption is one of the strategic stages in agribusiness management. However, just like the selection of commodities or the determination of location, the selection of technology adoption also faces multi-criteria conditions that lead to complexity. The choice of technology adoption is not as simple as whether this technology is cheap in terms of cost, but it also needs to be seen from other criteria

such as sociocultural, socio-economic, agroecological, institutional, and sustainability aspects (Arangurí *et al.*, 2025; Manzoor *et al*., 2025).

Overall, the studies examined show that FAHP in the evaluation of agricultural production technology and systems is generally used as a tool to manage the complexity of multi-criteria assessments, both in assessing the characteristics of technology and the impact of production systems on various performance indicators. However, the role of FAHP in most studies is still limited to the evaluation stage (Belaid *et al*., 2024; Sharma *et al*., 2025), ranking of technological alternatives (Zhang *et al*., 2020) and technological decision validation tools (Qureshi *et al.*, 2022). Meanwhile, its integration into the broader framework of agribusiness strategic decision-making, for example in long-term investment planning or production system development, is still relatively limited and opens up space for the development of further research.

3.2.4. The Role of FAHP in Supply Chain Strategy and Marketing

In the study of supply chain strategies, risk is a major concern in addition to efficiency. The movement of products from producers to consumers is prone to damage, loss, price fluctuations, demand uncertainty, and coordination disorders. The characteristics of agricultural products that are perishable, seasonal, and influenced by the environment further increase this uncertainty, so that risk management and mitigation are strategic aspects in decision-making.

Supply chain risk management is not only operational, but determines the sustainability and competitiveness of agribusiness. Decision-making involving risk prioritization, mitigation strategies, and distribution and marketing design is multi-criteria and often relies on subjective judgment. Therefore, the multi-criteria decision making (MCDM) approach, especially the Fuzzy Analytic Hierarchy Process (FAHP), has become relevant to integrate various economic, social, managerial, and technological dimensions (Simatupang *et al*., 2025; Suriani *et al*., 2025).

In some of the studies reviewed, the application of FAHP in supply chain and marketing strategies showed several specific patterns, ranging from weighting instruments (Atlı, 2024; Atli, 2025; Wahyuningtyas *et al.*, 2021) and as an evaluation instrument (Choirun *et al*., 2024). As a weighting instrument, FAHP plays a role in determining risk priorities for each supply chain actor. The weighting results then become the basis for the preparation of risk mitigation strategies. Meanwhile, as an evaluation instrument, FAHP is used to evaluate and determine alternative priorities for risk mitigation strategies. At this stage, FAHP becomes more integrated in a strategic decision-making framework.

Furthermore, based on studies conducted by Atlı (2024), Atli (2025) and Choirun *et al*., (2024), it strengthens the findings that in strategic decision-making related to risks full of uncertainty and assessment subjectivity, the fuzzy logic based approach is considered more appropriate than the crisp approach. In addition, these studies prove that the use of quantitative and qualitative data in a single mathematical framework is not an obstacle to the use of FAHP. However, the methodological findings in the study of Wahyuningtyas *et al*. (2021) related to the attention to the Consistency Ratio (CR) below the threshold of 0.100, open up conceptual questions regarding the consistency of the application of FAHP, considering that philosophically this method is designed to accommodate the uncertainty and inconsistency of human judgment.

3.3. Directions and Opportunities for the Development of FAHP Research in Agribusiness Strategic Decision Making

Looking at the current development of the implementation of FAHP, the future advanced study space is wide open, especially regarding the use of FAHP in other strategic aspects in agricultural and agribusiness management. The high compatibility of FAHP allows researchers to use a variety of different methods within a single strategic decision-making framework. Then the development of digitalization of agribusiness management such as IoT, smart farming, sensor technology and information technology systems is also noteworthy because it is able to provide a real-time database. This provides the possibility for the study of real-time data-driven decision-making with FAHP so that adaptive decisions can be made to change so quickly. However, it should be noted that FAHP is essentially static and based on expert assessment, so its application in a real-time data-based environment still requires further methodological development, for example through integration with decision support systems (DSS).

In addition, the development of artificial intelligence (AI) and machine learning technology also offers other opportunities in terms of speed, accuracy, consistency and complexity. This development will allow the trend of FATP-based research to move from simple criteria weighting activities to a more complex and integrated analytical framework. In terms of research topics, current and future trends regarding studies in the agriculture and agribusiness sectors will always be associated with sustainability. Meanwhile, from several

studies reviewed, especially on the application of FAHP in strategic decision-making, it has not been explicitly seen to be related to sustainability. This is a research gap that can be filled by researchers. Studies related to strategic decision-making should be encouraged not only to be purely technical-operational, but also to consider social, economic and environmental aspects as dimensions of sustainability. Of course, this condition will add to the complexity of the study and this is where the role of FAHP or other fuzzy approaches is expected to be more relevant in the future.

4. CONCLUSIONS

The results of the study show that FAHP has been widely used in various contexts, such as selection of superior commodities, land suitability evaluation, production technology assessment, and supply chain strategy. Its main advantage lies in its ability to deal with uncertainty and subjective judgments, making it relevant for complex and multidimensional decisions. However, the literature mapping also shows a fairly consistent pattern that in most studies, FAHP is still used primarily as an alternative weighting and ranking tool. Such use tends to stop at the technical-analytical level and has not been widely developed within the framework of long-term strategic planning or in the perspective of agribusiness sustainability.

The main scientific contribution of this study lies in the affirmation and clarification of this pattern, as well as in the effort to reposition FAHP in the strategic management of agribusiness. The novelty produced is not in the development of new methods, but in the mapping of the use of FAHP in the agribusiness sector and in the affirmation that there is a gap between technical use and its potential strategic integration. These findings provide a conceptual basis for the development of further research that integrates FAHP more fully within strategic decision frameworks, including in sustainability issues and data-driven systems.

It must be acknowledged; this study has some limitations. First, as a review of the narrative literature, the analysis conducted was qualitative and did not use a systematic approach or quantitative meta-analysis. Second, the scope of the literature is limited to publications in specific periods and databases, so there may still be relevant research that has not been accommodated. Third, the synthesis carried out depends on the author's interpretation of the studies studied.

In terms of practical implications, the results of this study show that FAHP can be used by policymakers, agribusiness managers, and strategic planners not only to evaluate alternatives operationally, but also to formulate long-term priorities. By incorporating the dimensions of sustainability, risk, and market dynamics into the decision-making hierarchy structure, FAHP can help formulate investment directions, resource allocation, and more adaptive agribusiness development strategies. The integration of FAHP with data-driven systems and digital platforms also has the potential to strengthen a more structured and transparent decision-making process.

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