Prospective user interfaces for decision-making processes in multidimensional agriculture

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Abstract. Prospective user interfaces play a crucial role in supporting decision-making processes within the multifaceted landscape of agriculture. This study aims to develop a software tool that integrates prospective user interfaces with the Analytic Hierarchy Process (AHP) model to assist in selecting agrochemicals based on criteria such as price, environmental impact, and toxicity. By leveraging dynamic visual tools and interactive interfaces, the proposed system empowers farmers and stakeholders to anticipate and evaluate future scenarios effectively in the context of diverse agricultural dimensions. The integration of prospective user interfaces with the AHP model enhances decision-making by providing a structured framework to prioritize criteria and alternatives. This facilitates informed and sustainable agricultural practices while addressing complex challenges related to environmental impact and economic viability. The software tool will enable users to input their preferences, weigh different criteria according to their importance, and generate recommendations based on the AHP analysis. This study highlights the importance of technological innovation in advancing decision-making capabilities within multidimensional agriculture, ultimately contributing to more efficient and responsible agricultural practices.

Keywords: Analytic hierarchy process, decision-making, multifunctional agriculture, human-computer interaction , prospective user interface.

1 INTRODUCTION

Agriculture plays a crucial role in modern society, providing food, employment, and contributing significantly to the global economy. However, the current growth model of agricultural production presents challenges that raise concerns about environmental and social sustainability. This study aims to develop a comprehensive decision-making model for agriculture. It considers economic factors, environmental impact, and consumer safety. By addressing these dimensions, the goal is to improve economic profitability while promoting sustainable and safer agricultural practices.

1.1 The problem statement.

The current trajectory of agricultural production growth is unsustainable due to its negative impacts on natural resources and the environment. Up to 40% of the planet's land is degraded, affecting half of humanity, as prices rise in the context of rapid climate change, increasing scarcity, and the rapid degradation of natural resources and other factors affecting the planet. A crisis approach is needed to conserve, restore, and use land sustainably [1]. Given the various issues in the agricultural sector and the growing need for a new perspective and growth in the development of technologies in this field, and since this is an area where research and development of functional prototypes are quite necessary, given that many developed models are redundant as noted in the development of the state of the art, the development of new technologies and techniques is necessary to meet the needs of the new agricultural model, which no longer relies on indicators such as performance or profit but instead ventures into the new multidimensional model that is based on or incorporates the three dimensions of sustainability: environmental, social, and economic, with objectives including environmental conservation, rural development, human nutrition and health, and farmer productivity and profitability [2]. Furthermore, given the continuous change in how user interfaces are developed and modeled, with a focus on making them increasingly user-friendly, innovative, and effective, improving communication between devices and users, and focusing on design, usability, and user experience [3].

A prospective interface refers to a tool or approach used to explore, understand, and/or evaluate potential future scenarios and facilitate informed decision-making. These provide a framework for user visualization and interaction with information, allowing them to anticipate changes and identify future opportunities and challenges in a given context. Prospective interfaces in agriculture provide farmers and planners with the ability to foresee and prepare for impending changes, helping them to identify and adopt more sustainable and resilient agricultural practices. They provide valuable information for evidence-based decision-making, and the use of prospective tools in agriculture helps farmers better understand risks and opportunities, enabling them to make more informed and strategic decisions. According to a report from the Food and Agriculture Organization (FAO) [4], prospective planning is crucial for addressing the challenges of climate change, resource scarcity, and increasing food demand. With the development of the following thesis work, we seek to develop a system to support decision-making, using an efficient method for multicriteria decision-making and implementing the concept of prospective interfaces. This system should meet the requirements of the new agriculture, known as multidimensional or multifunctional agriculture, allowing improvements in this sector, and supporting research and technology implementation in this area, while also considering the concept of responsible innovation.

1.2 Objectives

General objective: Design prospective user interfaces for decision-making in the agricultural field that support concepts such as sustainable agriculture and multidimensional agricultural systems, based on the pillars of the three dimensions of sustainability: environmental, social, and economic.

Specific objectives.

- Analyze the data of decision-makers in the multidimensional agriculture sector and characterize them through user profiles.
- Develop a prototype (software) based on prospective user interfaces corresponding to user profiles, enabling the evaluation of decision-making in multidimensional agricultural systems.
- Validate the proposed system to analyze and confirm the correct implementation of interfaces for user profiles and effective decision-making in a multidimensional agricultural context.

2 METHODOLOGY

This study aims to implement technology that supports decision-making in the field of multidimensional agriculture, utilizing the Analytic Hierarchy Process (AHP) decision-making method. This field encompasses various dimensions and criteria, making it extensive and complex, requiring consideration of multiple aspects to ensure effective decision-making. It is crucial in this context to address the diverse perspectives and criteria involved in agricultural decision-making, avoiding conflicts between farmers' prioritized objectives and those inherent in multidimensional agriculture. Additionally, the goal is to characterize each user involved in this process to understand their needs and preferences better. To achieve this, a tool will be implemented using AHP to select the appropriate agrochemical based on the user's preferred criteria model(s). Prospective interfaces will be utilized to enhance the user's understanding of the selection model(s), facilitating more effective decision-making in multidimensional agriculture.

2.1 Analytic hierarchy process

Since its inception, the Analytic Hierarchy Process (AHP) has been a valuable tool for decision-makers and researchers, establishing itself as one of the most widely used tools for decision-making involving multiple criteria. Over the years, numerous prominent works based on AHP have been published, addressing a wide variety of applications in various fields. These applications range from planning and selecting the best alternative to resource allocation, conflict resolution, optimization, and many other areas. Additionally, extensions and numerical enhancements of AHP have been developed, further enriching its utility and versatility in the decision-making domain [5].
The Analytic Hierarchy Process (AHP) is based on the following steps for decision-making:
1. The objective to be achieved is determined.
2. The criteria and sub-criteria to be considered are defined, structuring them in a hierarchy.
3. Each criterion is compared with its sibling criteria (same parent) using pairwise comparisons to determine the importance of each criterion in the hierarchy.

4. For each criterion C, pairwise comparisons between alternatives must be made to obtain the priorities of each alternative with respect to C. This step should only be carried out for those criteria that do not contain sub-criteria.
5. All priority vectors obtained in the previous step are combined, resulting in a new vector representing the final ranking of the alternatives.

The comparisons are made considering the Saaty scale:

Intensity of importance	Definition
1	Equal importance
3	Somewhat more important
5	Much more important
7	Very much more important
9	Absolutely more important
2, 4, 6, 8	Intermediate values

Fig. 1. The fundamental scale of AHP

With the above, we present the Analytic Hierarchy Process (AHP) Tree Diagram for Decision Making that will encompass our solution. This AHP (Analytic Hierarchy Process) diagram will be essential for analyzing and prioritizing evaluation criteria such as price, toxicity, and environmental impact, helping us make informed and effective decisions. Through this process, we will establish a clear and objective hierarchy of relevant factors, facilitating the selection of the best option within our solution.

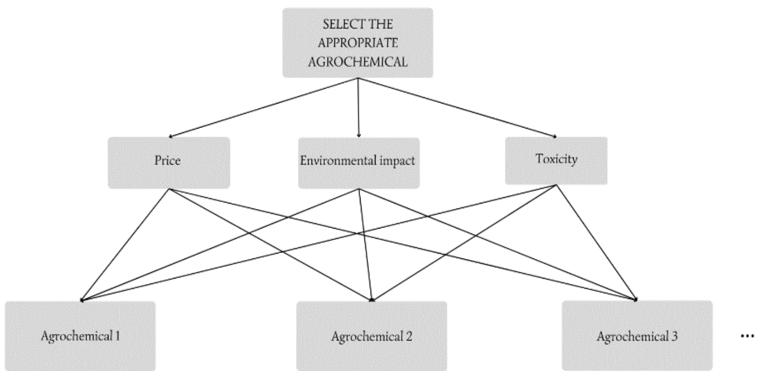

Fig. 2. Analytic hierarchy process (AHP) tree diagram for decision making

2.2 Prospective user interface

The field of Human-Computer Interaction (HCI) is paramount in the design of interactive systems. HCI focuses on understanding how humans interact with technology and aims to improve this interaction to optimize usability, accessibility, and user satisfaction. Strategies are discussed for designing more effective and appealing interfaces,

along with ethical considerations in the design of interactive systems. In summary, HCI underscores the importance of creating technology systems that are more user-friendly, accessible, and impactful, ultimately enhancing the relationship between humans and technology.[6]
The focus of Human-Computer Interaction (HCI) is to create interfaces where users have greater control and understanding of their decisions. This is where the concept of prospective user interfaces comes into play. These interfaces serve as tools or approaches to explore, understand, and evaluate potential future scenarios. They facilitate informed decision-making by providing users with a framework to visualize and interact with information. This enables users to anticipate changes, identify future opportunities, and recognize challenges within a specific context. Lastly, our software will implement these prospective interfaces when users rank criteria using sliders and visualize this model through matrices and pie charts. This will allow them to interact more effectively with the information, enabling exploration of future scenarios and informed decision-making.

3 PRELIMINARY RESULTS

Presented below are the latest advancements in our solution, which enable users to dynamically rank various criteria using interactive selection and slider controls. This approach enhances usability by providing a more intuitive and flexible way for users to engage with the ranking process. By allowing dynamic selection and adjustments through sliders, users can efficiently assess and prioritize criteria according to their preferences and needs. Users will have the ability to log in to the tool, ensuring that their data is securely stored within it. Our solution leverages modern technologies such as React for frontend development and MongoDB for data storage, ensuring efficiency and scalability.

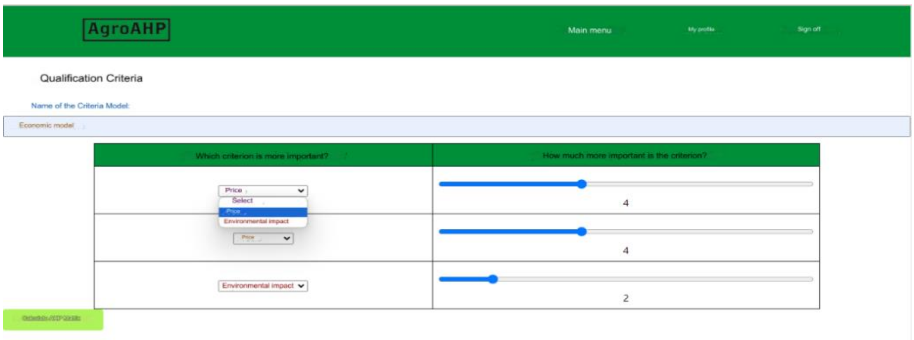

Fig. 3. Ranking criteria: user interface for evaluating economic, environmental, and toxicity.

Once the user has confirmed their selections and criteria rankings, our tool will automatically generate the AHP matrix specific to their evaluation model. This AHP matrix will provide a structured representation of preference relationships between criteria, enabling a more accurate and objective assessment. In addition to the AHP matrix, we will present a pie chart that visually illustrates the percentage of importance assigned to each criterion by the user. This graphical representation will facilitate result interpretation by highlighting the most relevant criteria within the decision-making context.

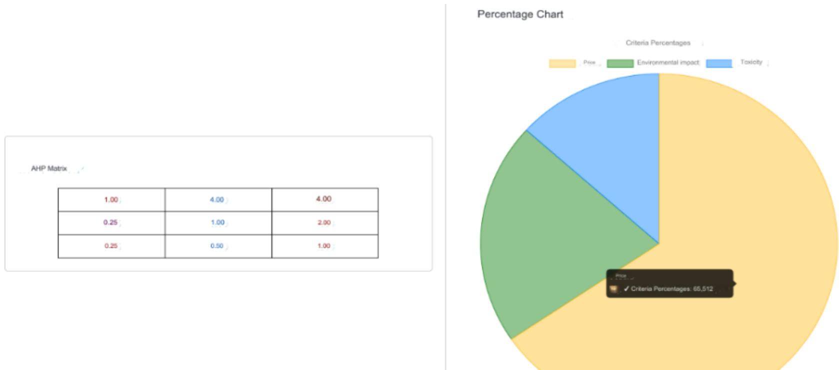

Fig. 4. Visualizing criteria evaluation: matrix and pie chart

4 CONCLUSIONS

The Analytic Hierarchy Process (AHP) is an effective tool for supporting complex decision-making. It facilitates the process by breaking down the problem into a hierarchy of criteria and alternatives, allowing for clearer and more structured evaluations. By integrating both quantitative and qualitative data, AHP helps assign weights to criteria based on their relative importance, reducing subjectivity, and improving decision quality. Its transparency and methodological rigor also enhance communication and consensus among decision-makers. In summary, AHP is a valuable tool that enhances and justifies complex decisions.

Visualizing the percentage of importance assigned to each criterion, users will gain a clearer understanding of their preferences and be able to identify the most important criteria and their relative impact on decision-making. If the initial results are not satisfactory, users can adjust the weights to see how they impact decisions. This flexibility supports continuous improvement, allowing for better decision-making over time as priorities and insights evolve. Visual representations like diagrams or matrices make these changes visible to users, enhancing their understanding of the decision-making process.

Additionally, AHP opens avenues for further research and development. Its versatility and applicability across various domains encourage exploration into additional methodologies and tools that can complement and enhance decision-making processes.

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