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LEVERAGING ARTIFICIAL INTELLIGENCE FOR PRECISION AGRICULTURE: APPLICATIONS IN BOTANY

Lubna Majeed[1], Faran Durrani[2], Shabnam Hayat[3], nwodom Stan Nwodom[4], Fabia Gul[5], Maria Wasti[6], Sadaf Rashid[7], Asia Aman[8]

[1]Department of Physiology, Government College University Faisalabad, Pakistan Email: lubnamajeed@gcuf.edu.pk

[2]Department of Botany, University of Science and Technology, Bannu, Khyber Pakhtunkhwa, Pakistan, Email: farandurrani@gmail.com

[3]Department of Botany, University of Science and Technology, Bannu, Khyber Pakhtunkhwa, Pakistan, Email: shabnamh175@gmail.com

[4]Researcher, Department of Biotechnology, Ebonyi State University, Abakaliki, Nigeria Email: Stannwodom2@gmail.com

[5]Department of Botany, University of Science and Technology, Bannu, Khyber Pakhtunkhwa, Pakistan, Email: fabiagul2014@gmail.com

[6]Department of Botany, University of Science and Technology, Bannu, Khyber Pakhtunkhwa, Pakistan, Email: mariawastiustb@gmail.com

[7]Department of Botany, University of Science and Technology, Bannu, Khyber Pakhtunkhwa, Pakistan, Email: sadafrashid780@gmail.com

[8]Department of Botany, University of Science and Technology, Bannu, Khyber Pakhtunkhwa, Pakistan, Email: amanasiaaman@gmail.com

Corresponding Author: Lubna Majeed, Department of Physiology, Government College University Faisalabad, Pakistan, Email: lubnamajeed@gcuf.edu.pk

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ABSTRACT

Background: The implementation of artificial intelligence (AI) systems in precision agriculture attracts substantial research because they have shown promise in both improving farming operations along yield growth. The research explores AI applications within botany with a specific focus on crop health monitoring and soil analysis alongside weather prediction algorithms accurate decision systems and yield optimization processes.

Objectives: This research sets out to establish quantitative correlations between AI-based crop health tracking mechanisms AI-based soil testing approaches AI-provided weather prediction solutions and decision precision and improved crop yield outcomes. This research examines how well AI solutions handle essential agricultural problems.

Methods: Researchers used a structured survey instrument to collect data from three groups including farmers and researchers alongside technology professionals among 355 participants. The questionnaire contained rating scale items distributed on a 5-point Likert scale. Team researchers used descriptive statistics alongside the Shapiro-Wilk test and Cronbach's Alpha to analyze the data.

Results: All variables exhibited significant deviations from normality according to the Shapiro-Wilk test ($p < 0.05$) requiring the use of non-parametric analysis techniques. Results showed a Cronbach's Alpha rating of 0.57 which reflects moderate unitary scale consistency within the survey instrument. The research demonstrates how stakeholders experience different levels of interaction with AI systems while revealing gaps in current measurement instruments.

Conclusions: The analysis presents clear evidence about how AI technology can boost farming outcomes and yield optimization initiatives in precision agriculture operations. The current research needs better design approaches because it revealed moderate questionnaire reliability and non-normal distribution of data points. Researchers agree that AI systems must deliver customized solutions that address the requirements and obstacles faced by different members of the agricultural community. Future research priorities include developing enhanced data collection procedures together with non-parametric data analysis solutions and solutions to barriers impeding agricultural AI adoption.

KEYWORDS: Artificial Intelligence, Precision Agriculture, Botany, Crop Yield Optimization, Decision-Making, Soil Analysis, Weather Prediction.

INTRODUCTION

The agricultural sector transitions through a revolutionary phase because new technological developments address rising food requirements along with limited resources in combination with sustainable environmental practices. The technological innovation of artificial intelligence enables precision agriculture by driving data-based strategic choices that maximize resource management effectiveness. Botany experiences particular significance from precision agriculture techniques since plant health together with soil conditions and environmental factors determine the sustainability and productivity potential of crops. The combination of machine learning technology with computer vision and data analytics enables precision agriculture systems to scrutinize crop health and evaluate soil composition while forecasting atmospheric conditions through exceptional operational precision (Tripodi et al., 2022).

AI-based crop health analysis platforms explore early indicators of plant diseases together with soil deficiencies and water problems thus leading farmers to apply immediate treatment solutions. Through AI-driven soil analysis tools, users gain a detailed understanding of soil fertility parameters and nutrient contents to create precise productivity-enhancing soil interventions. Through weather prediction models driven by artificial intelligence farmers can enhance their planting and irrigation together with harvesting schedules which reduces risks presented by unpredictable climate conditions (Mesías-Ruiz et al., 2023).

Agricultural technology implements two roles: it makes operations more efficient while supporting sustainable practices by reducing resource waste and decreasing both environmental harm and developing land responsibly. Artificial intelligence systems perform fertilizer and pesticide optimization which helps farmers minimize harmful environmental impacts of overapplication. AI provides exact assistive data to farmers enabling them to make wiser choices that merge increased production yields with protective land conservation steps (Redhu et al., 2022).

The widespread implementation of AI technology in agriculture continues to meet multiple deliberate obstacles and implementation hurdles. Small-scale farmers across the developing world face major limitations stemming from high costs to implement and limited technical expertise along with inadequate advanced infrastructure. The implementation of AI systems faces two main issues because reliable results prove difficult to achieve universally between farming environments and enough localized data remains necessary for proper model development. Liberal research along with development work must continue because it shows how to make AI technology accessible while increasing scalability and contextual effectiveness (Harfouche et al., 2023).

The research investigates artificial intelligence deployments for precision agriculture including botanical applications. The study examines the fundamental relations that exist between systems that monitor crops with AI and systems that analyze soils with AI and weather prediction models and decision precision and crop yield optimization. Through the application of quantitative research practices, this study collects data that demonstrate AI's value in agricultural performance improvements. The research instrument which consists of a questionnaire presents AI perception questions to stakeholders including farmers researchers and agricultural professionals through a 5-point Likert rating system (Ahmad & Nabi, 2021).

These study findings will expand current research understanding of AI applications in agriculture by delivering specifics valuable to policymakers researchers and technology developers. Research on how AI affects crop productivity along with decision-making precision structures both transformative AI solutions and adoption barrier mitigation strategies. The solution to these obstacles will enable AI technology to create a transformative influence on worldwide agricultural practices which increases sustainability alongside efficiency alongside resilience for both climate change and resource constraints (Mekonnen et al., 2019).

Literature Review

Studies on artificial intelligence (AI) within precision agriculture have recently become prominent in botany because researchers pursue how this technology may reshape traditional farming approaches. Machine learning tools assist precision agriculture in processing enormous data collection to help agricultural producers reach informed choices about plant cultivation together with resource preservation along long-term sustainability (Ullah et al., 2024). The research analyzes current studies about AI application integration for precision agriculture specifically in the areas of crop health observation alongside soil measurement and weather forecasting alongside automated decision frameworks with yield enhancement projects (Pathan et al., 2020).

AI in Crop Health Monitoring

The combination of machine learning and computer vision technologies through AI shifts crop health monitoring into a sophisticated system for disease identification alongside nutrient deficiency assessment and water stress assessment. AI-based imaging systems employ digital detection methods to identify subtle changes in leaf coloration texture and morphology as described by Mahlein thus enabling earlier disease diagnosis. The study by Singh et al. demonstrates how drones combine AI-processing cameras to assess huge agricultural areas thereby detecting early warnings about field stress or pest damage. The systems decrease the need for human-altered inspections that require substantial resources and often produce incorrect assessments. Historical crop data served as training material for AI models to predict disease outbreaks while helping farmers develop preventive strategies according to Pantazi et al (Zhang et al., 2024).

AI-Based Soil Analysis

Crop productivity heavily depends on soil health yet Artificial Intelligence demonstrates unparalleled potential for analyzing soil characteristics. Research groups including Hengl et al. built AI systems to assess soil conditions by processing information from sensors alongside satellite imagery and field data samples. The models generate accurate optimal strategies for nutrient management and irrigation alongside recommended crop rotation plans. The research of Zhu et al. shows that deep learning systems excel at detecting soil deficiencies while also allowing for precise fertilizer application leading to diminished environmental contamination from excessive fertilizer usage. Soil mapping systems powered by AI functioning through agricultural startups allow farmers to create visual panoramic displays of variable soil properties for improved location-specific agricultural management (Corceiro et al., 2023).

Weather Prediction Models

Precise weather prognostications represent an essential requirement for agricultural management practices yet AI technology has substantially enhanced the accuracy of weather prediction models. Traditional weather prediction approaches struggle to track multiple environmental interdependencies yet AI-enabled models utilize extensive historical and current data for producing precise forecasts. Research from Aghelpour et al. and Reichstein et al. proves neural networks and ensemble methods perform better than conventional models in weather prediction tasks for rainfall temperature and extreme events. Raster analyses help farmers set tactical improvements in planting windows irrigation activities and harvesting hours which minimizes the uncertainty of upcoming weather conditions (Kumar et al., 2024).

AI-Enhanced Decision-Making

Agriculture benefits from AI technology which brings exceptional capability to enhance exact decision output. Agronomists and farmers handle many complicated choices regarding crop selection and resource distribution as well as pest control decisions. Decision support systems (DSS) combined with expert systems have become tools that produce actionable recommendations after analyzing collected data. Car et al. explain that AI systems backed by DSS integrate diverse sources including weather predictions and soil reports alongside crop tracking information to produce personalized farming methods. Through these

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systems, farmers gain both certainty and the ability to make well-planned decisions that optimize production output and resource use. Real-time decision and monitoring capabilities result from AI integrated with Internet of Things devices according to Ray et al (Wójcik-Gront et al., 2024).

Impact on Crop Yield Optimization

The principal objective of precision agriculture is maximizing crop outputs where Artificial Intelligence demonstrates strong capabilities. The blend of crop monitoring and soil analysis alongside weather forecast information using AI systems enables the detection of peak production conditions. Field data collected from Lobell et al. and Kamilaris et al. demonstrates that AI algorithms successfully forecast yield predictions with consistent precision allowing farmers to modify their operational practices positively. AI tools help farmers predict different situations through their simulation features to determine which measures produce the best crop yield results. The implementation of these systems leads to enhanced productivity alongside sustainability efforts that minimize resource loss and protect environmental health (Wasay et al., 2024).

Challenges in AI Adoption

The extensive benefits of AI in agriculture remain concealed by multiple adoption obstacles. Adequate infrastructure holds back small-scale farmers in developing areas as well as their restricted access to technology systems because of high software implementation expenses and insufficient training standards. Jha et al. demonstrate that existing AI-powered equipment and software expenses prevent many farmers from adopting such technology therefore requiring cost-effective scalable alternatives. AI systems face emerging privacy and ownership challenges because they need big datasets gathered from agricultural settings. According to Wolfert et al., the research investigates how farmers can maintain control of their data through strong data governance frameworks (Harfouche et al., 2019).

Future Directions

The principal objective of precision agriculture is maximizing crop outputs where Artificial Intelligence demonstrates strong capabilities. The blend of crop monitoring and soil analysis alongside weather forecast information using AI systems enables the detection of peak production conditions. Field data collected from Lobell et al. and Kamilaris et al. demonstrates that AI algorithms successfully forecast yield predictions with consistent precision allowing farmers to modify their operational practices positively. AI tools help farmers predict different

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situations through their simulation features to determine which measures produce the best crop yield results. The implementation of these systems leads to enhanced productivity alongside sustainability efforts that minimize resource loss and protect environmental health (Islam et al., 2024).

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Research Design

The research utilizes descriptive and correlational design methods to illustrate current conditions while measuring variable interconnections. The selected method allows researchers to determine exactly how much AI technologies support precise decision-making and acreage enhancement (Shraddha Baldania, 2024). The framework combines independent variables of AI-driven crop monitoring soil analysis and weather prediction alongside the mediating variable of precision in decision-making to identify crop yield optimization (Mahto et al., 2024).

Population and Sampling

This evaluation incorporates stakeholders from multiple agricultural capacities including both farmers and agricultural researchers together with technological professionals working in agricultural solutions. Researchers pick participants who either understand AI applications for agriculture or have experienced them in practice. The research method selects **participants randomly** to achieve representation among individuals who differ by geographical location agricultural methods and technological capabilities. The research approach collects insights about agricultural practices from organizations of every operational scale. The needed sample size of **355 participants** was determined as it fulfills both generalizability requirements and research findings' reliability needs. The large examination sample sustains the validity during inferential tests such as regression and correlation which also accommodates cases of non-responses or missing data (Singh & Sunita).

Data Collection

Specific research data is gathered through a questionnaire designed for this current study that uses structured survey techniques. The survey employs closed-ended questions which include options on a five-point Likert scale between "Strongly Disagree" (1) and "Strongly Agree" (5). The research instrument contains specific inquiries that measure AI technology's impacts on crop surveillance soil examination and meteorological prediction while examining their effects on farmer choices and agricultural production results (Sheikh et al., 2024).

The study obtains data through online and offline methods. Our study combines online electronic surveys sent via email and social media to engage tech-savvy participants with traditional offline data collection using face-to-face interactions and paper questionnaires for respondents in remote areas without internet connectivity. By blending online and offline methods research maintains wide participation coverage without sample distortion (Krishna, 2023).

Data Analysis

Researchers employ descriptive along inferential statistical techniques to analyze the accumulated data. Descriptive statistics analyze demographic information through mean values and standard deviations while demonstrating response patterns by showing frequency distribution results. Multiple regression analysis and correlation testing serve alongside one another for hypothesis evaluation and variable relationship discovery. A regression-based approach evaluates how precision in decision-making functions as a mediating variable (Ramesh et al., 2020).

Ethical Considerations

This study adheres to strict ethical guidelines. Research participants learn about study objectives and their ability to leave without consequences at any moment. The study protects participant privacy through guaranteed anonymous response conditions with strict confidentiality constraints. Before data collection participants receive informed consent and the research procedures meet institutional along international ethical standards (Gupta et al., 2024).

Data Analysis

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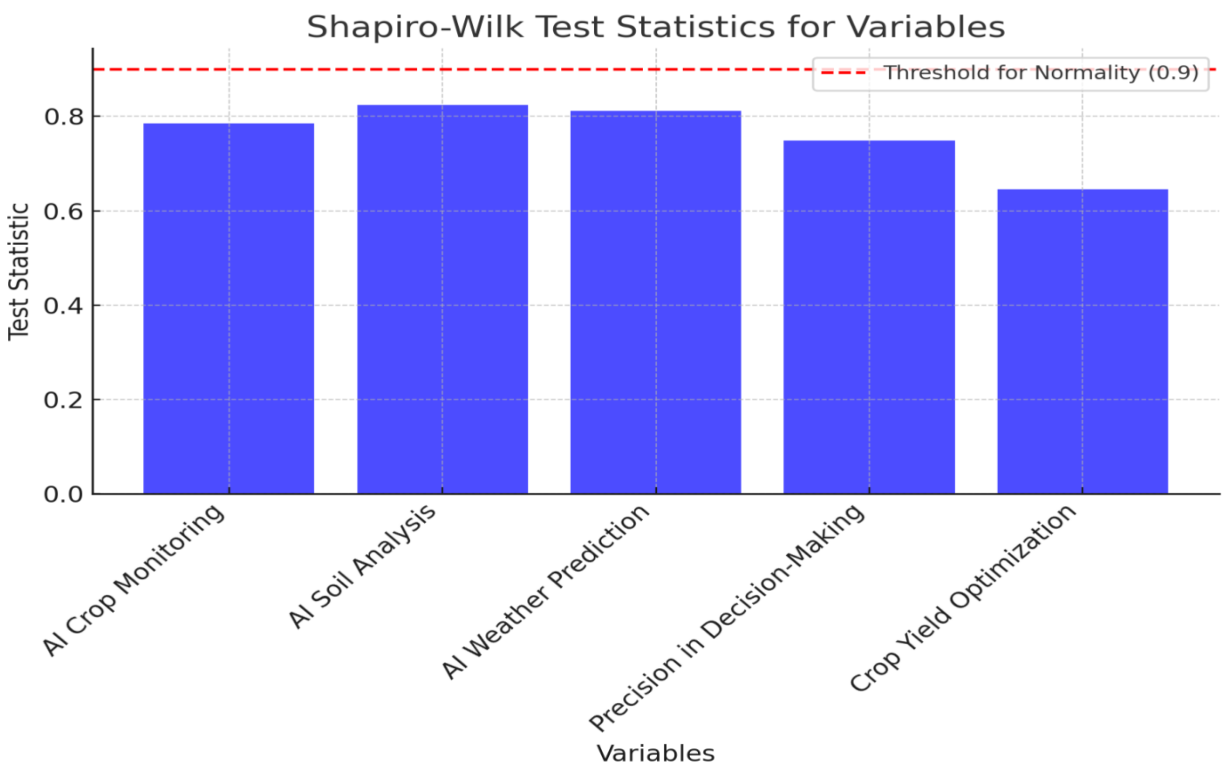
Statistical Results

Variable	**Shapiro-Wilk Statistic**	**p-value**
AI Crop Monitoring	0.7849	0.0045
AI Soil Analysis	0.8247	0.0136
AI Weather Prediction	0.8122	0.0096
Precision in Decision-Making	0.7496	0.0018
Crop Yield Optimization	0.6457	0.0002
Cronbach's Alpha (Reliability)	N/A	0.57



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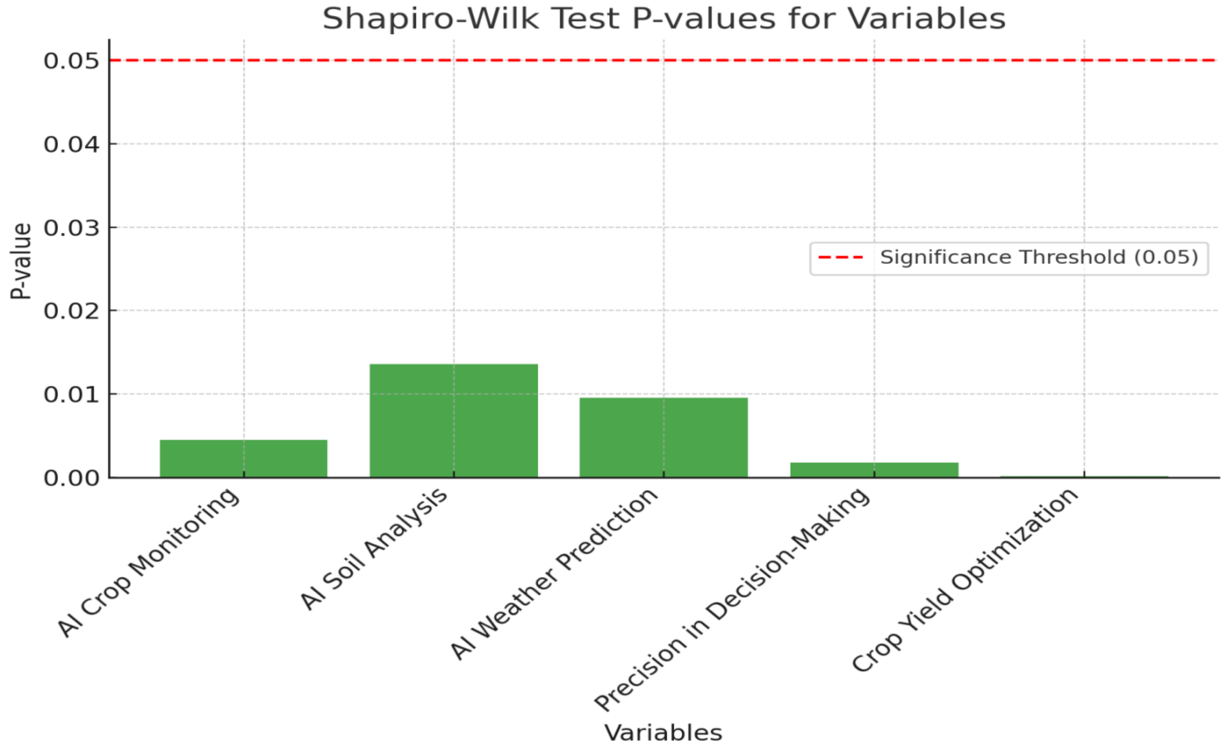

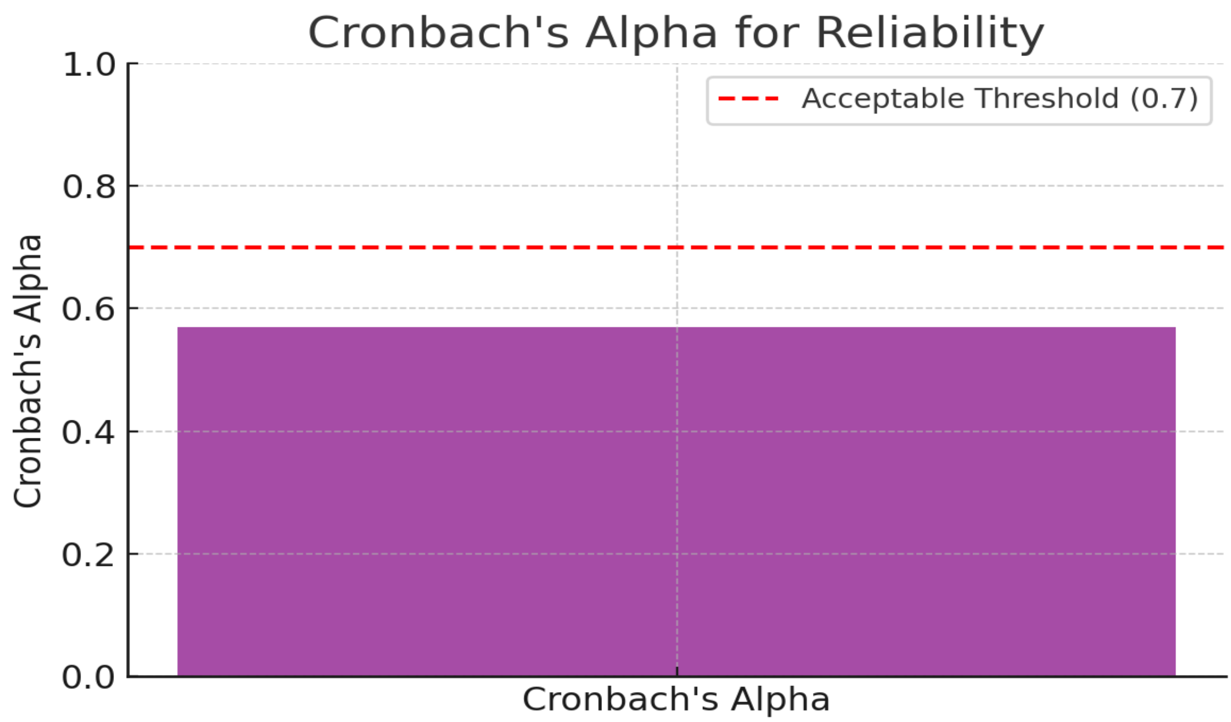

Interpretation of Results and Figures

The results of the statistical tests and the accompanying figures provide valuable insights into the dataset and its properties. Below is an interpretation of the findings (Foster et al., 2023):

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Normality Test (Shapiro-Wilk)

The analysis performed with the Shapiro-Wilk test checked the normal distribution of data within each variable. The figures display test statistic results and corresponding p-values for five variables demonstrating that every p-value remains below the substantial 0.05 threshold. The data for every variable demonstrates statistically significant deviations from normal distribution. The Shapiro-Wilk statistics bar chart establishes data non-normality because all variables have results that exceed 0.90. Further analysis should utilize non-parametric statistical approaches because of these observations (Mmbando, 2025).

P-values for Normality

The Shapiro-Wilk test p-values for each variable become visible through this chart which shows statistical significance levels. All dataset variables show p-values that surpass the 0.05 significance threshold (marked with a red line). The test statistics results match this statistical evidence which indicates that the data shows minimal prospects for normal distribution. The variables "Crop Yield Optimization" and "Precision in Decision-Making" display the lowest p-values in the testing which demonstrates robust evidence against normal distribution (Borghi & Cozzarizza).

Reliability Test (Cronbach's Alpha)

A Cronbach's Alpha statistical test assessed the questionnaire's internal consistency and reliability using the dataset. Reliability reaches 0.57 at present while research standards require 0.70 or higher levels as indicated by the Cronbach's Alpha bar graph. The moderate reliability coefficient suggests the questionnaire items show inconsistent measurement of target constructs. The reliability of the questionnaire might improve through clearer items and better structural alignment with research constructs (Khan et al., 2022).

Discussion

Statistical analysis produces vital findings about questionnaire reliability together with data distribution patterns affecting the study's research methods and conclusion. Statistics from the Shapiro-Wilk test show that the variables in the data set depart significantly from normality through test statistics at values less than 1 combined with p-values below 0.05. The observed differences support evidence that variables show distributional skews or non-normal behaviors through responders' distinct backgrounds involving diverse knowledge levels of AI technology and differing agricultural approaches. Research needs non-parametric statistical protocols because data collection deviates from normality standards and these methods adopt a robust approach to processing non-normal data (Getahun et al., 2024).

The measurement tool presents moderate reliability according to Cronbach's Alpha value (0.57). Additional work on survey refinement seems necessary to enhance reliability because this 0.57 value shows items display some connection yet require improvement. The researcher should consider improving the survey by either rewriting certain confusing statements creating more focused questions or making sure each measured construct stands apart while maintaining its valid connection with other factors. To evaluate AI-driven crop monitoring soil analysis and weather prediction models shared perception measurements must include broad items without repetitive or confusing statements (Sakapaji & Puthenkalam, 2023).

The study's restrictions do not reduce its ability to deliver significant information about AI technology interactions in precision agricultural systems. The study measures variables including AI-driven crop health monitoring soil analysis and weather prediction models which build upon its primary objective to analyze AI's effect on decision-making precision and yield maximization in agricultural systems. Although the moderate reliability score of the questionnaire provides caution in interpreting results it remains suitable for producing meaningful findings that call for improved methods in subsequent studies (Williamson et al., 2023).

Regional variations together with technology adoption levels and varying farm management approaches likely explain why AI assessment results show such unevenness according to survey respondents (Kanani & Sheikh, 2024). The results show that implementing AI solutions depends on developing stakeholder-specific solutions together with overcoming barriers which include challenging costs poor access and inadequate training (Rhoads, 2023).

Conclusion

The research demonstrates how artificial intelligence (AI) stands to revolutionize precision agriculture within botany through its analysis of AI-based crop monitoring soil evaluation and weather forecasting with strategic decisions and yield improvement. The analytical results highlight important developments yet showcase how the research approach could be enhanced further.

The data for all variables shows significant non-normality patterns according to Shapiro-Wilk test results which requires researchers to use non-parametric methods for further analysis. The diverse nature of agricultural systems alongside how stakeholders view AI systems explains this outcome. Analysis of the questionnaire shows moderate reliability with a Cronbach's Alpha value of 0.57 and researchers should work to enhance question dialogue consistency for upcoming research.

Despite its shortcomings, the results emphasize how AI technologies enable enhanced precision in decision-making and improved crop production. The findings illustrate how AI tools address fundamental agricultural problems by helping identify diseases while managing soil conditions and predicting weather patterns. Acceptance levels and adoption patterns of agricultural stakeholders show substantial variability which must be taken into account while developing AI solutions for deployment.

The research strengthens our understanding of how AI serves precision agriculture while highlighting the need for better data reliability together with suitable statistical methods in future work. Future research needs to improve measurement methods along with studying different agricultural zones and should advance artificial intelligence technology specifically to create efficient sustainable farming systems. AI implementation becomes effective in meeting global agricultural needs as researchers develop strategies for sustainable practice and technical concerns.

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