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# Cows, Code, and Curds: Google Bard Transforms Smallholder Dairy Farming in Bangladesh

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**ABSTRACT:**

Dairy farming constitutes a vital component of Bangladesh's economic and food security landscape, yet prevailing practices grapple with challenges such as low productivity, inefficient resource utilization, and limited sustainability. This investigation delves into the potential of Bard AI, a robust language model, to contribute to the sustainability of dairy farming in Bangladesh. Through a statistical analysis of the relationships between Bard AI and key factors, the study reveals promising prospects for AI-driven interventions. Positive correlations between Bard AI and Developing New Products, Disease Prevention and Control, and Product Quality Control suggest its capacity to foster innovation, disease management, and enhanced product quality. Although Developing New Products doesn't directly influence Sustainability, the positive associations identified for Disease Prevention and Control and Product Quality Control underscore their pivotal roles in establishing a sustainable dairy industry. In light of these findings, the conclusion outlines potential applications of Bard AI in Bangladesh, ranging from knowledge dissemination platforms to disease prediction systems and resource optimization solutions. The study advocates for further research to delve into specific applications and assess the economic and environmental benefits of Bard AI, positioning it as a transformative tool to empower Bangladeshi dairy farmers toward sustainable practices with positive implications for both economic and environmental outcomes.

**Keywords:** Bard AI, Sustainable Dairy Farming, Bangladesh, Data-driven insights, AI-powered interventions.

## 1. Introduction

The modern world has experienced a significant change driven by the widespread impact of artificial intelligence, leading to unprecedented advancements in automation, data processing, and decision-making systems. This evolution has significantly augmented operational efficiency across diverse industries. Nevertheless, integrating artificial intelligence presents intricate challenges, encompassing ethical considerations and the prospect of workforce displacement (Mithany et al., n.d.). The paradigm shift brought about by AI-powered chatbots is reshaping our interaction with technology, providing round-the-clock assistance, and emulating natural conversation (Følstad et al., 2021). Envision a benevolent genie within the pocket, poised to address inquiries, schedule appointments, or engage in casual conversation at any moment. AI-powered chatbots gained significant attention with the introduction of ChatGPT in November 2022, followed by the unveiling of Google Bard in March 2023 (Dwivedi et al., 2023; Qin et al., 2023). These events represented significant achievements in the continuous development of conversational artificial intelligence. These chatbots are demonstrating their adaptability across a wide range of fields.

The dairy industry holds a pivotal position in Bangladesh's economy, particularly emphasizing the crucial involvement of smallholder dairy farmers. The sector has experienced steady expansion, serving as a crucial revenue stream for many rural households in Bangladesh, where nearly 66% of rural families are involved in cattle husbandry to fulfill their personal milk requirements, and any surplus milk is generally vented within local markets, with the average dairy farm consisting of 3.5 cattle, indicative of moderate yield levels (Datta et al., 2019). With its 1.85% contribution to the national economy, the dairy sector underscores its substantial importance within the broader agricultural landscape. Acknowledging the specific percentage attributed to the dairy industry provides a more nuanced understanding of its distinct economic influence, emphasizing the need to recognize the diverse contributions of various sectors (Livestock Economy at a Glance, n.d.). Google Bards can play a significant role in upscaling sustainability in the small-holder dairy farming industry.

The objective of this research is to assess the impact of Google Bard on the sustainability of smallholder dairy farming in Bangladesh. This will be accomplished by conducting an examination of the application's characteristics and capabilities, which encompass disease prevention and control, product quality assurance, and the creation of innovative products. The dependent variable in this study is sustainability in Bangladeshi smallholder dairy farming, while the independent variables are disease prevention, product quality control, and new product creation. The research aims to assess the impact of Google Bard on these independent variables and the impact of these independent variables on the overall sustainability of smallholder dairy farming practices.
This paper is structured in a systematic manner, commencing with a thorough exploration of existing research concerning smallholder dairy farming and the influence of Google Bard in the literature review section. This particular segment is of utmost importance as it provides essential context and establishes the foundation for the subsequent investigation. Following this comprehensive review, the methodology section meticulously delineates the processes and tools applied in the research, ensuring transparency in the framework that guides the study.

Subsequent to this, the narrative smoothly progresses into the results and findings segment, where the empirical outcomes of the research are presented and scrutinized. This particular

segment serves as the central focus of the research, examining the intricate dynamics surrounding disease prevention, product quality control, and the development of new products, and how these factors collectively impact the long-term viability of smallholder dairy farming in Bangladesh.

The concluding portion amalgamates the study's key insights, establishing connections among the literature, methodology, and empirical findings. This statement summarizes the research's overall impact on the academic field, highlights any significant implications or recommendations, and provides a coherent conclusion to the scholarly investigation conducted in this project. The conceptual framework for the study is as follows,

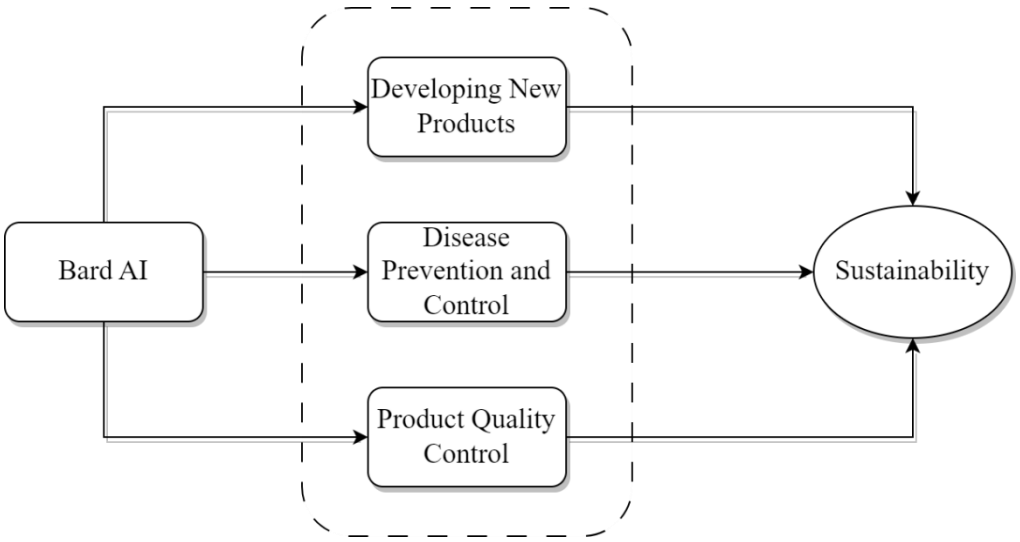


Fig. 1 Conceptual Framework (Proposed By Authors)

**Hypotheses**

H1: A correlation exists between Bard AI and the development of new products in smallholder dairy farming.
H2: A correlation exists between Bard AI and Disease Prevention and Control in smallholder dairy farming.
H3: A correlation exists between Bard AI and Product Quality Control in smallholder dairy farming.
H4: A correlation exists between Sustainability and the development of new products in smallholder dairy farming.
H5: A correlation exists between Sustainability and Disease Prevention and Control in smallholder dairy farming.
H6: A correlation exists between Sustainability and Product Quality Control in smallholder dairy farming.

## 2. Literature Review

**Google Bard**

Google Bard is an AI chatbot created by Google AI. It uses the Gemini language model, which has been extensively trained on a large dataset containing both text and code. Google Bard is skilled at answering questions, generating different types of creative text, and facilitating language translation, all in a natural and conversational manner (Google Updates Bard Chatbot with 'Gemini' A.I. as It Chases ChatGPT - The New York Times, n.d.). Bard boasts a vast reservoir of data, having undergone extensive training on a colossal dataset,

rendering it a valuable research instrument for information retrieval and the identification of potential correlations across diverse disciplines. Its capacity for interdisciplinary exploration facilitates the amalgamation of information from various domains, fostering novel research inquiries and bridging disciplinary gaps. Bard not only excels in retrieving data but also demonstrates exceptional proficiency in developing unique text formats like as poems, scripts, and code. This ability fosters new thinking and provides valuable support for the creation of hypotheses or study ideas (Tapping into Google Bard's Potential, n.d.). Bard serves as both an educational instrument and a personalized learning assistant, adapting explanations and exercises to the specific needs of each student. In doing so, it encourages self-directed study and fosters the growth of critical thinking abilities. The conversational interface developed by Bard improves accessibility and has the potential to democratize education and research by providing similar possibilities to students with various levels of ability and experience (Kamalov et al., 2023). Physicians demonstrated strong overall performance, particularly in the realm of case reports; however, Google Bard exhibited comparable diagnostic proficiency in common cases (Hirosawa et al., 2023). The influence of the AI-based chatbot, Google Bard, on dairy farming is diverse, spanning environmental sustainability, livestock management, and economic viability. The industry-changing potential of this technology resides in its capacity to offer invaluable assistance and insights that tackle critical challenges encountered in the dairy farming sector.

**Chatbots in Dairy Farming**

In the domain of dairy farming, chatbots offer prompt assistance to practitioners by furnishing them with significant knowledge pertaining to livestock management, environmental circumstances, and queries concerning farm operations. The incorporation of chatbots contributes to enhanced decision-making and increased efficiency in the daily functioning of dairy farmers. The utilization of machine learning and artificial intelligence in chatbots has provided us with the ability to understand the native language of users and facilitate more customized interactions with them (Talaviya et al., 2020). A Chatbot-Based E-System for Animal Husbandry was implemented by Gattani et al. (Gattani et al., 2023) in the Maharashtra region of India. This system incorporated E-Farming practices with the aim of augmenting sustainability. A scarcity of skilled laborers in Peru's agricultural sector hinders livestock producers' ability to obtain accurate and relevant information that is essential for providing optimal nutrition and care for dairy cows; consequently, this has a negative impact on productivity; Milchbot, a chatbot utilizing Watson Assistant and Discovery, addresses this gap by providing comprehensive responses to queries on feeding and care processes, exhibiting high usability and satisfaction ratings from both livestock producers and zootechnicians in its evaluation which is proposed by Herrera et al (Herrera et al., 2022). Furthermore, AI-powered chatbots, exemplified by Cersi, serve a critical function in predicting possible disruptions in the agricultural supply chain. It is crucial to emphasize that while these chatbots show great potential, they are essentially tools designed to support dairy farmers and should not be seen as substitutes for their knowledge (This AI Chatbot Can Help Predict Supply Chain Disruptions at Farms, n.d.). The human touch and experience of farmers continue to be indispensable in ensuring the well-being of their cows.

## 3. Materials and Methods

**Research Design**

The research commenced with an in-depth examination of relevant literature to establish a comprehensive background. Drawing from insights gained in the literature review, a conceptual model was formulated. Subsequently, data for model evaluation was gathered

through a survey. The suggested structure was evaluated using the Partial Least Squares Structural Equation Modelling (PLS-SEM) approach, and subsequently, the finalized version was suggested. The research design flowchart is depicted as follows, outlining the systematic progression of the study.

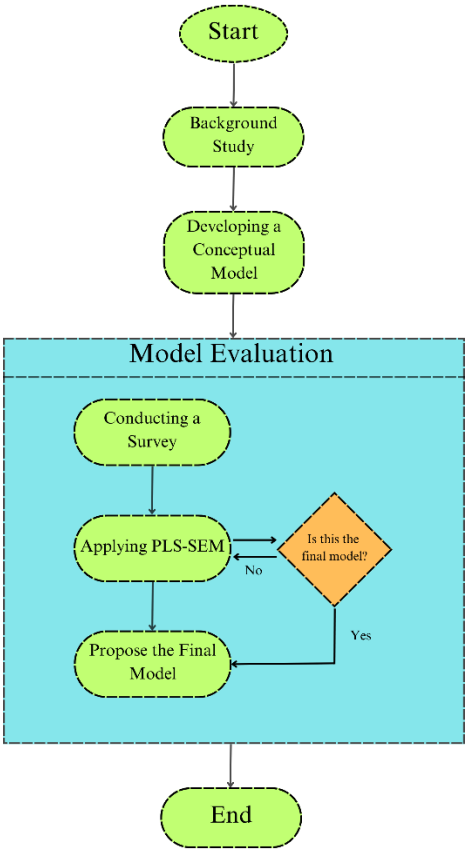


Fig. 2 Research Methodology Flowchart

**Data Collection**

The data collection for this study was conducted through a survey. The researchers paid a visit to the dairy center of Pran Dairy Ltd., located in Pabna, Bangladesh, on November 23, 2023. The primary aim of the expedition was to acquire practical knowledge in multiple facets of their means of subsistence, encompassing milk supply chains, agricultural infrastructure, production methodologies, and sustainability. Following a meticulous assessment of various sampling methods, the researcher opted for simple random sampling (utilizing a Disproportionate technique) due to the specific attributes of the population (smallholder farmers) and the disproportionate nature of characteristics such as family composition, education, number of cattle, herd size, cowsheds, and land ownership (Noor et al., 2022). The target population comprises 300 individuals registered with Pran Dairy Ltd for ten years or more who have successfully operated their farming activities, and the sample size was determined in accordance with Krejcie and Morgan's Table (1970) (Krejcie & Morgan, 1970). The investigator developed a survey tool encompassing 34 items in both English and Bengali languages. Within this set, ten items focus on gathering demographic information, while the remaining 24 questions utilize a 5-point Likert scale (ranging from 1, indicating "Strongly Disagree," to 5, representing "Strongly Agree").

**Data Selection**

Out of the 300 Dairy farmers, 270 dairy farmers took part in the survey. Nevertheless, out of the initial 270 survey participants, 50 were omitted for providing incomplete responses, and an additional 11 were eliminated for displaying obvious straight-line or dubious responses. With a response rate of 70%, this study surpassed the minimum requirement established by W. Black and Babin, which stipulates that survey research must have a response rate of no less than 50% (Black & Babin, 2019).

**Data Analysis**

The Partial Least Square Structural Equation Modeling (PLS-SEM) method was employed to analyze the data (Hair et al., 2021). PLS-SEM, or partial least squares structural equation modeling, is one of the most widely utilized methods for analyzing multivariate data. Structural equation modeling utilizes this statistical technique to facilitate the estimation of complex cause-effect relationships that incorporate latent variables (Hair Jr. et al., 2021). It functions as a viable substitute for covariance-based structural equation modeling (CB-SEM) and is widely implemented across a wide range of disciplines such as engineering, marketing, information systems, medicine, psychology, political science, and environmental science. PLS-SEM diverges from the covariance-based structural approach by virtue of its component-based estimation methodology (Astrachan et al., 2014).

**Data Analysis Tools**

The survey was administered using Google Forms (Google Forms: Online Form Creator | Google Workspace, n.d.), an online form creation tool provided by Google Workspace. After collecting the data, SPSS (Downloading IBM SPSS Statistics 26, n.d.), a statistical software package, was used for data preparation and identifying outliers. Finally, the PLS-SEM model was used using the SmartPLS 3.2.8 software. According to Joe F. Hair, SmartPLS is a notable improvement in latent variable modeling. It combines advanced techniques like PLS-POS, IPMA, and complex bootstrapping algorithms, all presented in a user-friendly graphical interface (SmartPLS, n.d.). The model implemented using the smartPLS software is presented below:

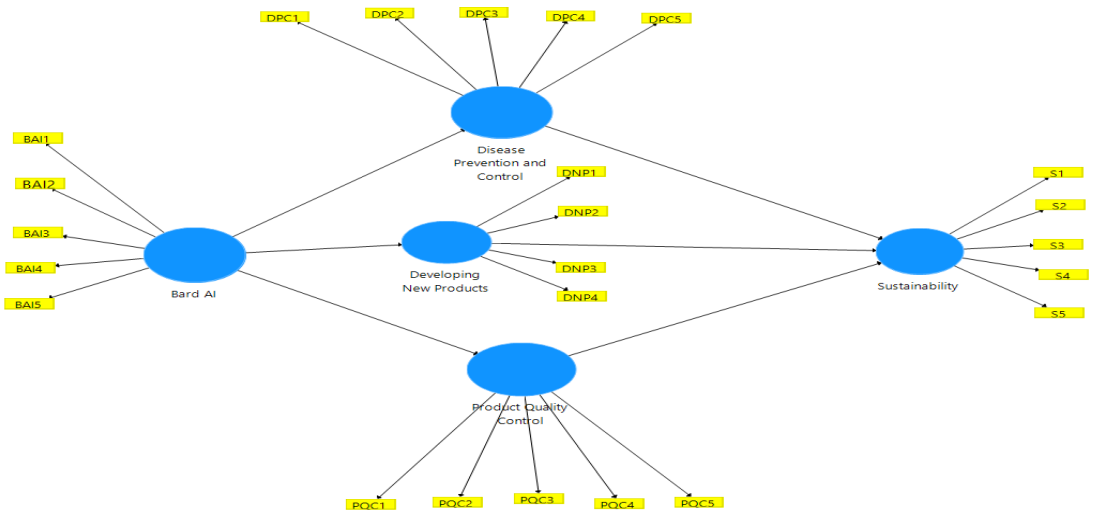


Fig. 3 Conceptual model using SmartPLS

## 4. Results and Findings

To pinpoint the predominant factor influencing the sustainability of the smallholder dairy farm, the study concentrated on the analysis of independent variables. Employing the PLS-SEM algorithm facilitated this analysis, implemented through the SmartPLS 3.2.8 software, renowned for its proficiency in PLS-SEM algorithm application. The outcomes of this algorithm application are visually represented in Figure 4, elucidating the structure of both the inner and outer models of PLS-SEM. Moreover, Table 1 provides a succinct overview of the suggestions obtained from the PLS-SEM analysis.

Table 1 Bootstrapping Parameters

| | |
|---|---|
| Subsamples | 1000 |
| Amounts of Result | Complete Bootstrapping |
| Test type | Two Tail |
| Significance Level | 0.05 |

In the context of Partial Least Squares Structural Equation Modeling (PLS-SEM), bootstrapping is a method for evaluating the statistically significant nature of various conclusions. Bootstrapping is a technique that uses data resampling to estimate the sampling distribution of statistics. It is a nonparametric method. This technique enables the examination of path coefficients, Cronbach's alpha, $R^2$ values, and other model attributes. Complete bootstrapping provides comprehensive insights and detailed information concerning the model's performance and validity.


Fig. 4 PLS algorithm outcome with Path Coefficients, Outer Loadings and Cronbach's alpha value

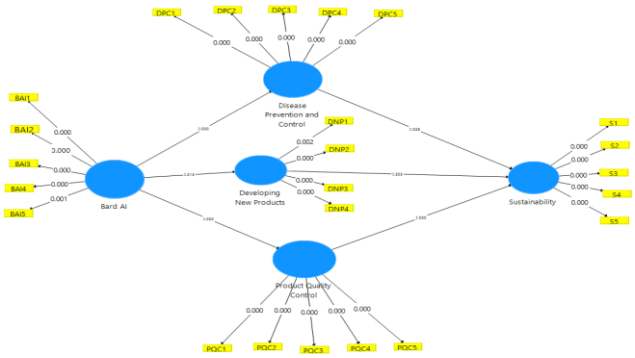


Fig. 5 Bootstrapping outcome with P-values

**Convergent Validity**

Convergent validity, which is a part of construct validity, assesses how well a measurement corresponds with other assessments that aim to capture the same underlying concept. It quantifies the level of consistency that a measurement demonstrates with other measurements that aim to assess the same concept (Cheah et al., 2018). In the study, the researchers utilized convergent validity to evaluate the reliability and authenticity of their survey instrument. This involved comparing the survey scores with those obtained from established measures associated with factors such as Bard AI, Disease Prevention and Control, Developing New Products, Product Quality Control, and Sustainability.

Table 2 Construct Reliability and Validity

| | **Cronbach's Alpha** | **rho_A** | **Composite Reliability** | **Average Variance Extracted (AVE)** |
|---|---|---|---|---|
| Bard AI | 0.761 | 0.869 | 0.837 | 0.532 |
| Developing New Products | 0.716 | 0.839 | 0.820 | 0.547 |
| Disease Prevention and Control | 0.818 | 0.860 | 0.880 | 0.607 |
| Product Quality Control | 0.869 | 0.937 | 0.906 | 0.664 |
| Sustainability | 0.891 | 0.911 | 0.919 | 0.696 |

The table presents a comprehensive evaluation of the reliability of four constructs. This assessment includes measures such as Cronbach's alpha, rho A, composite reliability, and average variance extracted (AVE). Cronbach's alpha and rho A measure of internal consistency, where a threshold of 0.7 or greater is regarded acceptable (Forero, 2014; Usage of Rho_A Reliability Coefficient - Forum.Smartpls.Com, n.d.). Composite dependability, which takes into consideration the amount of elements, must also be equal to or greater than 0.7 (Bacon et al., 1995). The AVE (Average Variance Extracted) is a measure used to evaluate the extent to which a concept is accurately represented by its indicators. A value of 0.5 or greater is considered satisfactory (dos Santos & Cirillo, 2023). Strong internal consistency and convergent validity are indicated in the table for all four constructs. Although Bard AI exhibits the lowest Cronbach's alpha and composite reliability, its AVE remains acceptable. Developing New Products shows slightly lower values, yet still falls within acceptable ranges. Product Quality Control exhibits the second-highest values in all metrics, after Disease Prevention and Control. To summarize, the table confirms the dependability and accuracy of all four concepts within their specific areas.

Table 3 R Square values

| | **R Square** | **R Square Adjusted** |
|---|---|---|
| Developing New Products | 0.017 | 0.012 |
| Disease Prevention and Control | 0.084 | 0.080 |
| Product Quality Control | 0.117 | 0.113 |
| Sustainability | 0.387 | 0.378 |

Table 3 presents the R-squared and modified R-squared values for four separate regression models. The R-squared measures the percentage of variation in the dependent variable that is accounted for by the independent variables (Ringle et al., 2023). The modified R-squared factor analyzes the total number of distinct variables when determining how well the model

fits (Akossou & R., 2013). The R-squared values for all four models are comparatively small, suggesting that the independent variables do not account for a significant proportion of the variability observed in the dependent variable. Furthermore, the adjusted R-squared values continue to be poor, indicating a lack of proper fit for the data. Possible explanations for the low R-squared values include the potential inadequacy of the selected independent variables in accurately representing the intended constructs, the exclusion of essential factors, or the unsuitability of the models for the given data. The detailed breakdown of the table reveals specific R-squared and adjusted R-squared values for each model, shedding light on the limited explanatory power of the variables within the regression models.

**Discriminant Validity**

The Fornell-Larcker criterion is a benchmark against which the discriminant validity of measurement models is assessed (Afthanorhan et al., 2021). The method in question involves contrasting the relationships between a specific construct and various other constructs, and additionally determining the square root of the average variance retrieved by that construct. In order to establish discriminant validity, it is necessary for the average variance extracted to exceed the correlations. This safeguards that a construct is substantially more closely linked to its own indicators than to the indicators associated with other constructs.

Table 4 Fornell-Larcker Criterion

| | **Bard AI** | **Developing New Products** | **Disease Prevention and Control** | **Product Quality Control** | **Sustainability** |
|---|---|---|---|---|---|
| Bard AI | 0.729 | | | | |
| Developing New Products | 0.130 | 0.740 | | | |
| Disease Prevention and Control | 0.289 | 0.338 | 0.779 | | |
| Product Quality Control | 0.342 | 0.210 | 0.271 | 0.815 | |
| Sustainability | 0.105 | 0.495 | 0.487 | 0.331 | 0.835 |

The heterotrait-monotrait ratio of correlations (HTMT) is a quantitative measure used to analyze the similarity of latent variables. It is specifically used to evaluate the discriminant validity of measurement models in structural equation modeling. This ratio assesses the average correlation between indicators across different constructions, either in terms of arithmetic or geometric mean, in comparison to the average correlation between indicators inside the same construct, specifically using the geometric mean. The HTMT method guarantees the accurate assessment of the correlation between hidden variables, so confirming that the measures of various constructs are truly separate from one other. This, in turn, validates the distinctiveness of the measurement models (Hamid et al., 2017).

Table 5 Heterotrait-Monotrait Ratio

| | **Bard AI** | **Developing New Products** | **Disease Prevention and Control** | **Product Quality Control** | **Sustainability** |
|---|---|---|---|---|---|
| Bard AI | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Developing New Products | 0.236 | | | | |
| Disease Prevention and Control | 0.380 | 0.516 | | | |
| Product Quality Control | 0.385 | 0.242 | 0.317 | | |
| Sustainability | 0.165 | 0.542 | 0.551 | 0.350 | |

**Hypothesis Testing**

The t-statistic serves as a quantification of the disparity between the estimated value of a parameter and its hypothesized value, presented in relation to its standard error (Bahadur, 1952). Frequently utilized in hypothesis testing through Student's t-test, it aids in deciding whether to endorse or refute the null hypothesis. The p-value represents the likelihood of obtaining outcomes from the test which are equivalent to or more severe than the observed outcome, on the premise that the null prediction is correct (Thiese et al., 2016). A reduced p-value implies more convincing proof in support of the other possibility, resulting in the dismissal of the null hypothesis as well.

Table 6 Hypothesis Testing

| **Hypotheses** | | **Original Sample (O)** | **Sample Mean (M)** | **Standard Deviation (STDEV)** | **T Statistics (\|O/STDEV\|)** | **P Values** | **Decisions** |
|---|---|---|---|---|---|---|---|
| H1 | Bard AI -> Developing New Products | 0.130 | 0.149 | 0.054 | 2.410 | 0.016 | Accepted |
| H2 | Bard AI -> Disease Prevention and Control | 0.289 | 0.302 | 0.050 | 5.769 | 0.000 | Accepted |
| H3 | Bard AI -> Product Quality Control | 0.342 | 0.347 | 0.047 | 7.243 | 0.000 | Accepted |
| H4 | Developing New Products -> Sustainability | 0.350 | 0.334 | 0.281 | 1.244 | 0.214 | Rejected |
| H5 | Disease Prevention and Control -> Sustainability | 0.322 | 0.302 | 0.151 | 2.129 | 0.034 | Accepted |
| H6 | Product Quality Control -> Sustainability | 0.170 | 0.162 | 0.079 | 2.170 | 0.030 | Accepted |

The table outlines six hypotheses concerning the associations among four variables: Bard AI, Developing New Products, Disease Prevention and Control, and Sustainability. The statistical analysis comprises the original sample data (O), sample mean (M), standard deviation (STDEV), t statistics (|O/STDEV|), p-values, and judgments made using a preset importance level. Hypotheses 1, 2, and 3 are accepted, indicating substantial evidence supporting the

relationships between Bard AI and Developing New Products, Disease Prevention and Control, and Product Quality Control. Hypothesis 4 is rejected due to insufficient evidence supporting the relationship between Developing New Products and Sustainability. Hypotheses 5 and 6 are accepted, revealing significant evidence supporting the relationships between Disease Prevention and Control, Product Quality Control, and Sustainability. The primary discoveries emphasize the beneficial relationships between Bard AI and progress in the development of innovative goods, prevention and management of diseases, and the quality control of items. Additionally, disease prevention and control and product quality control exhibit a positive correlation with sustainability. Notably, Developing New Products does not exhibit a significant relationship with Sustainability based on the available data.

## 5. Conclusion

The information provides vital insights into how Bard AI may contribute to the advancement of sustainable dairy production in Bangladesh. While the hypotheses underwent comprehensive scrutiny, delving into the specific associations between Bard AI and sustainability-related factors in the Bangladeshi dairy sector reveals crucial implications for future advancements. Key findings indicate that Bard AI demonstrates positive correlations with Developing New Products, Disease Prevention and Control, and Product Quality Control, showcasing its potential as a pivotal tool for Bangladeshi dairy farmers to innovate solutions, implement robust disease prevention strategies, and elevate product quality standards. The non-significant direct relationship between Developing New Products and Sustainability signals a need for further exploration to identify specific products or technologies crucial for promoting sustainability. Additionally, the significant associations observed between disease mitigation and management, Product Quality Control, and Sustainability underscore the vital role of these practices in promoting the long-term sustainability of the Bangladeshi dairy industry. The implications for Bangladesh encompass the development of Bard AI-powered platforms, utilization for disease prediction and prevention, promotion of AI-driven solutions for resource efficiency, and the facilitation of digital traceability systems.

In order to fully harness the revolutionary potential of Bard AI in promoting sustainable dairy farming in Bangladesh, it is imperative that future research focuses on performing case studies, creating tailored Bard AI models, and examining the economic and environmental advantages. It is crucial to recognize that these findings are preliminary, and a more thorough examination is necessary to obtain conclusive insights into the role of Bard AI in promoting sustainable dairy manufacturing throughout Bangladesh.

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