Unlocking the Power of Business Analytics in Underutilized Sectors: A Case Focus on Rural and Small-Scale Agriculture

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Abstract- ***This study examines the role of business analytics in enhancing efficiency and sustainability within underutilized sectors, with a specific focus on rural and small-scale agriculture. Using a case study approach and survey data collected from 10 students pursuing business analytics, the research explores awareness, applicability, and perceived impact of data-driven tools in agricultural practices. Findings indicate a growing recognition of analytics in areas such as yield forecasting, resource planning, and market access. While students acknowledge the potential of analytics to improve decision-making and productivity, challenges such as limited digital exposure in rural settings, infrastructural constraints, and lack of targeted training persist. The study recommends capacity-building initiatives, improved access to analytical tools, and curriculum integration to bridge the gap between analytics education and real-world agricultural needs.)***

I. INTRODUCTION

In recent years, the agricultural sector—particularly rural and small-scale farming—has faced significant challenges, ranging from climate variability and resource scarcity to market unpredictability and technological isolation. These challenges have underscored the urgent need for innovative, data-driven solutions that can optimize productivity, reduce inefficiencies, and support sustainable growth. Business analytics has emerged as a promising tool to address these issues by transforming raw data into actionable insights for better decision-making and strategic planning.

Business analytics in agriculture refers to the systematic use of data analysis tools, statistical methods, and predictive models to enhance farm operations, supply chain efficiency, and resource management. When effectively applied, these tools empower farmers and agricultural stakeholders to make informed decisions on crop selection, irrigation scheduling, pest control, and market timing. This capability is particularly vital in underutilized and rural settings, where resources are limited, and the margin for error is narrow. The integration of analytics promotes agility—defined as the ability to adapt quickly to changing conditions such as weather fluctuations, market demand shifts, and policy reforms.

Simultaneously, there is a growing emphasis on aligning agricultural practices with sustainability frameworks. The circular economy (CE) has gained traction in this context, promoting a model that prioritizes resource efficiency, minimal waste, and regenerative practices. In rural agriculture, CE can manifest through practices like composting, crop rotation, precision farming, and the reuse of agricultural by-products. Business analytics plays a crucial enabling role by providing the data and insights needed to implement and monitor these sustainable practices effectively.

Despite the recognized benefits of both business analytics and circular economy models, their combined application in rural and small-scale agriculture remains relatively underexplored. There is a pressing need to understand how analytics tools can be leveraged in these contexts—not only to boost productivity and income but also to foster environmentally sustainable farming systems.

This study aims to explore how business analytics can unlock potential in underutilized agricultural sectors, using rural and small-scale farming as a case focus. By

examining perceptions, awareness levels, and practical barriers, the research evaluates how future professionals in business analytics—represented by a group of students—view the applicability and impact of these tools in rural settings.

To fill this gap, the study employed a mixed-method exploratory approach using a structured survey administered to 10 students. The research investigated students' understanding of analytics in agriculture, perceived advantages, potential challenges, and alignment with sustainable agricultural practices. The findings offer insights into how educational institutions and policy-makers can better prepare and deploy data-driven strategies for transforming rural agriculture.

In doing so, this paper answers the following core questions:
• Are students aware of and confident in the use of business analytics for agriculture?
• How can business analytics enhance agility and informed decision-making in small-scale farming?
• To what extent can analytics contribute to sustainable and circular agricultural practices?

By addressing these questions, this study provides valuable direction for stakeholders aiming to promote innovation, resilience, and sustainability in rural agricultural ecosystems through business analytics.

II. LITERATURE REVIEW

A. Business Analytics in Agriculture

The application of business analytics in agriculture extends far beyond the adoption of isolated digital tools. It involves the strategic integration of data collection, analysis, and interpretation into core farming activities—ranging from production planning and resource allocation to market forecasting and supply chain management. As noted by Wolfert et al. (2017), analytics in agriculture creates a data-driven ecosystem that enhances decision-making, improves efficiency, and supports sustainable practices.

Advancements in analytics platforms, mobile technologies, and remote sensing have opened new possibilities for even smallholder farmers to benefit from precision agriculture. However, in developing countries like India, the lack of digital infrastructure, insufficient data literacy, and limited access to customized analytics tools often limit the widespread adoption of such technologies. Studies by Mittal and Mehar (2016) indicate that while awareness of digital farming is increasing, the practical application of analytics remains inconsistent across rural regions.

Despite growing interest, there is limited empirical research assessing how emerging professionals—such as students in analytics programs—perceive the feasibility and impact of business analytics in rural agriculture. This highlights the need for context-specific, student-centred studies such as the present one.

B. Agricultural Agility Enabled by Data Tools

Agility in agriculture refers to the sector's ability to respond quickly to changing environmental, market, and policy conditions. Business analytics empowers such agility by enabling predictive capabilities (e.g., weather trends, pest outbreaks), optimizing resource allocation, and facilitating adaptive planning. According to Mazzocchi et al. (2009), access to accurate and timely data enhances farm-level responsiveness and minimizes risk in uncertain conditions.

In the context of rural and small-scale agriculture, agility is not merely a technological challenge—it requires localized data interpretation, community training, and contextual tool design. While large agribusinesses may already implement agile strategies using advanced analytics, smallholder farmers remain vulnerable to volatility due to limited decision support systems.

Thus, understanding how upcoming analytics professionals interpret and value agility in agricultural contexts becomes crucial for future policy and practice.

C. Circular Economy and Sustainability in Agriculture

The circular economy (CE) is gaining traction in agriculture as a framework that encourages regenerative, resource-efficient practices. CE in farming involves closed-loop systems such as

composting, intercropping, bio-fertilizer usage, and recycling of agricultural waste. Kirchherr et al. (2018) emphasize that CE promotes both ecological sustainability and economic resilience, making it highly relevant for rural and small-scale farmers operating under resource constraints.

Business analytics serves as a key enabler for CE practices by tracking input-output flows, identifying waste patterns, and optimizing farm-level resource use. Yet, in many rural settings, these analytics applications are either absent or underutilized due to the lack of awareness and training. While institutions and governments promote sustainability goals, there is a disconnect between policy frameworks and grassroots-level implementation.

This study recognizes the importance of exploring how analytics-literate individuals perceive the link between data tools and CE practices in agriculture, thereby bridging the gap between theoretical sustainability models and real-world application.

D. Linking Business Analytics, Agility, and Circular Economy

Although business analytics, agricultural agility, and circular economy frameworks have been explored in isolation, there is growing recognition of their interconnected value for instance, analytics-based irrigation systems improve water use efficiency while enabling real-time response to climate conditions—demonstrating how agility and CE can be simultaneously achieved.

This convergence points toward what scholars call a "data-enabled sustainable agriculture model," where farms operate flexibly, efficiently, and responsibly. However, most literature focuses on large-scale or Western agricultural systems. There is a notable gap in research involving underutilized sectors such as Indian rural agriculture—particularly from the perspective of young analytics professionals who will shape future interventions.

The present study addresses this gap by using student insights to examine how analytics tools can simultaneously promote productivity, adaptability, and sustainability in small-scale farming.

III. RESEARCH DESIGN

A structured questionnaire was developed to collect data from students enrolled in business analytics programs at Galgotias University, a reputed private institution in India. The questionnaire was administered via Google Forms and distributed digitally through academic communication channels and student networks. It consisted of both closed-ended (Likert scale, multiple choice) and open-ended questions, allowing respondents to share their knowledge, perceptions, and insights regarding the application of business analytics in rural and small-scale agriculture.

C. Sampling and Participants

The study targeted students currently pursuing undergraduate and postgraduate degrees in business analytics or related disciplines. A non-probability convenience sampling technique was employed, enabling efficient data collection from accessible and willing participants within a short period.

• Sample Size: 10 valid responses

• Demographics: Respondents comprised both male and female students aged between 20 and 27 years, primarily enrolled in postgraduate business analytics or MBA programs with a specialization in analytics.

D. Structure of the Questionnaire

The questionnaire was carefully structured to align with the key themes of the study: business analytics application, agricultural agility, and circular economy practices in rural farming. It included the following sections:

Demographics: Age, gender, program of study

- Awareness and Perception of Business Analytics: Understanding of analytics tools in the agricultural context
- Applicability and Benefits: Views on how analytics can improve decision-making, productivity, and efficiency in rural farming
- Agility in Agriculture: Perceptions of how data tools support flexibility, timely

response, and adaptability in farming operations

- Sustainability and Circular Economy: Awareness of eco-friendly practices enabled by analytics, such as resource optimization and waste reduction
- Challenges and Recommendations: Open-ended responses identifying barriers to implementation and suggestions for better integration of analytics in underutilized sectors

E. Data Analysis

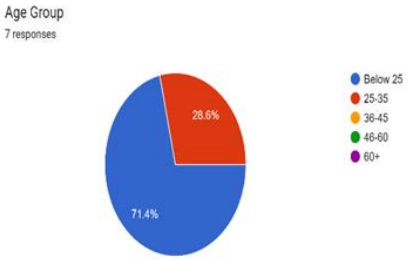
Quantitative data collected through the survey was analysed using descriptive statistical techniques, including frequency distributions and percentage analysis, with the help of Microsoft Excel. Visual tools such as bar charts and pie graphs were employed to represent response trends related to student awareness, perceived applicability of business analytics, and insights on agricultural agility and sustainability.

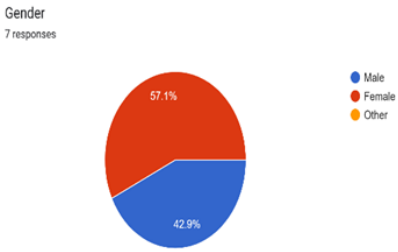
Recurring keywords and statements were categorized into themes such as “limited exposure,” “training requirements,” “data relevance,” and “potential for sustainability.” This approach helped contextualize the numerical findings and provided deeper insight into students' perceptions and interpretations of business analytics in the agricultural sector.

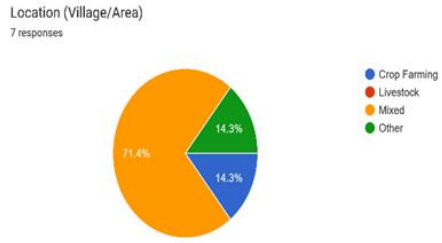
F. Ethical Considerations

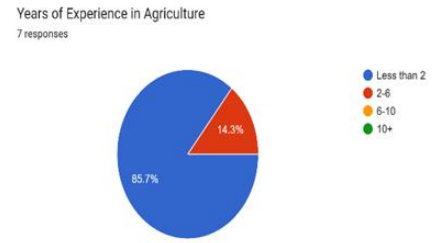
The study followed established ethical protocols for academic research. Participation was entirely voluntary, and all respondents were clearly informed that their responses would be used solely for educational and research purposes. No personally identifiable data was collected, ensuring respondent anonymity and confidentiality. All collected data was stored securely and accessed only by the researcher and the assigned academic supervisor.

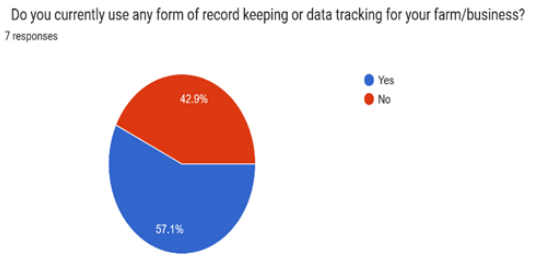
IV. DISCUSSION OF FINDINGS

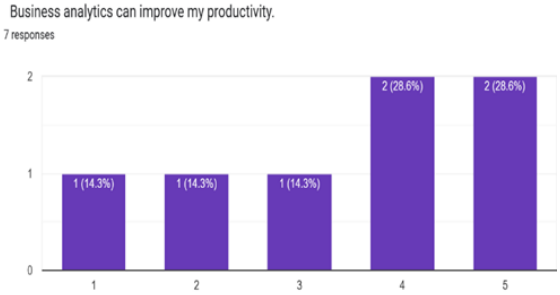


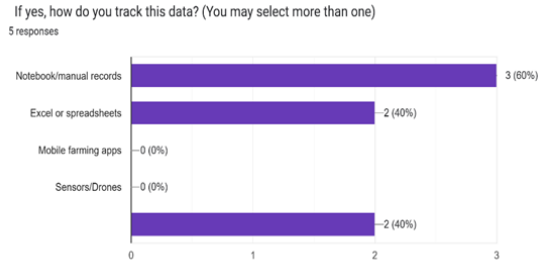


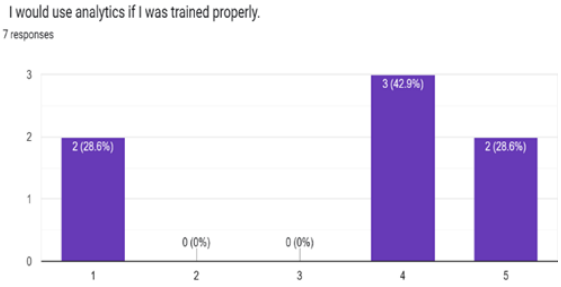


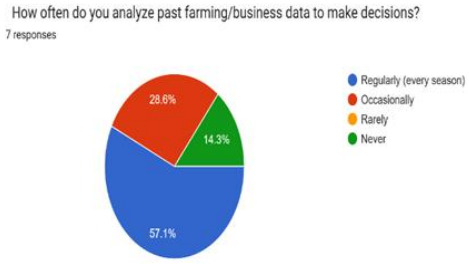


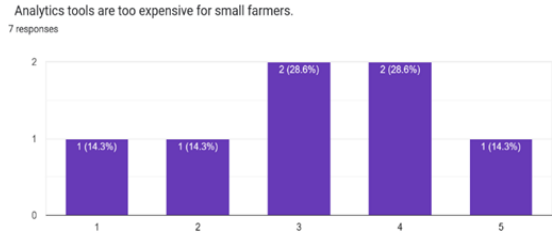

Do you currently use any form of record keeping or data tracking for your farm/business?
7 responses
42.9%
57.1%
Yes
No

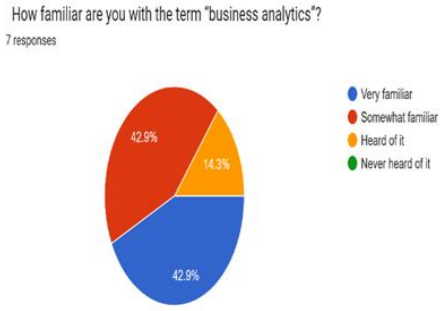

Business analytics can improve my productivity.
7 responses
1 (14.3%)
1 (14.3%)
1 (14.3%)
2 (28.6%)
2 (28.6%)

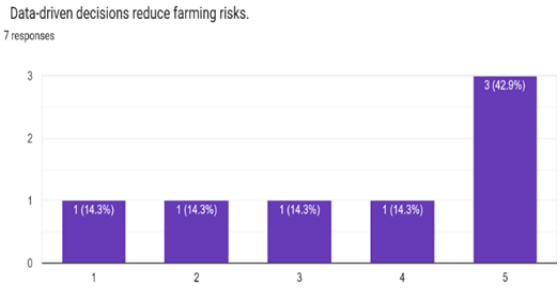

If yes, how do you track this data? (You may select more than one)
5 responses
Notebook/manual records
Excel or spreadsheets
Mobile farming apps
Sensors/Drones
3 (60%)
2 (40%)
0 (0%)
0 (0%)
2 (40%)

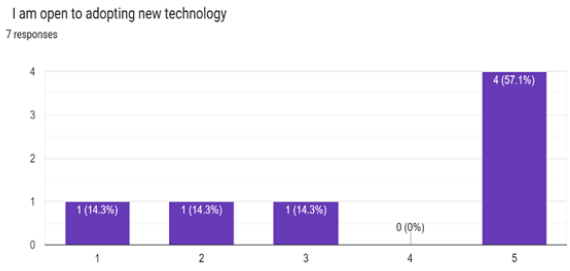

I would use analytics if I was trained properly.
7 responses
2 (28.6%)
0 (0%)
0 (0%)
3 (42.9%)
2 (28.6%)

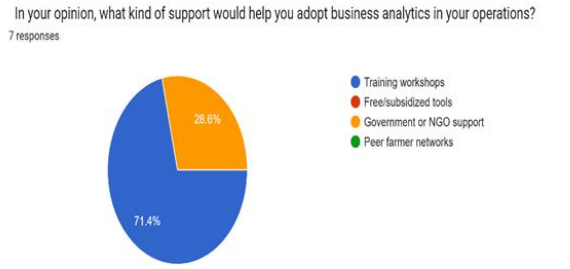

How often do you analyze past farming/business data to make decisions?
7 responses
28.6%
14.3%
57.1%
Regularly (every season)
Occasionally
Rarely
Never


Analytics tools are too expensive for small farmers.
7 responses
1 (14.3%)
1 (14.3%)
2 (28.6%)
2 (28.6%)
1 (14.3%)


How familiar are you with the term "business analytics"?
7 responses
42.9%
14.3%
42.9%
Very familiar
Somewhat familiar
Heard of it
Never heard of it


Data-driven decisions reduce farming risks.
7 responses
1 (14.3%)
1 (14.3%)
1 (14.3%)
1 (14.3%)
3 (42.9%)





1. Awareness of Business Analytics in Agriculture

- Yes: 9 students (90%)
- No 1 student (10%)

Discussion:

The high awareness level suggests that students are increasingly exposed to the role of business analytics in agriculture through academic programs and external sources. This reflects well on the relevance of analytics in current curricula. The small percentage lacking awareness highlights the need for better integration of agricultural case studies and practical exposure in business analytics courses.

2. Frequency of Digital Platform Usage

- Daily: 2
- Weekly: 3
- Occasionally: 4
- Rarely: 1

Discussion:

While 50% of respondents engage with agricultural analytics concepts regularly (daily or weekly), others show sporadic interaction. This inconsistency may be due to elective course availability or lack of hands-on exposure. Embedding agriculture-related data sets in projects or case-based modules could improve consistent engagement.

3. Ease of Understanding Analytics Applications in Farming

- Very Easy: 1
- Easy: 3
- Neutral: 2
- Difficult: 1
- Very Difficult: 3

Discussion:

Only 40% found it easy or very easy to understand analytics use in agriculture, while 40% found it difficult. The neutral responses may stem from limited context or technical jargon. Simplifying concepts with local farming examples and visual tools could significantly improve comprehension and application.

4. Training Received on Agricultural Data Tools

- Yes: 5
- No: 5

Discussion:
Half the students reported not receiving any specific training on analytics tools in the agricultural context. This training gap could hinder real-world readiness and confidence. Institutions should consider offering focused workshops, live case analysis, or online certifications tailored to agribusiness analytics.

5. Challenges Faced in Applying Analytics to Agriculture

- Limited exposure to Agri-data: 4
- Lack of practical tools: 2
- Insufficient mentorship: 2
- Other: 2

Discussion:
Lack of access to agricultural datasets and domain-specific tools is the most common barrier. Limited mentorship also affects students' ability to explore

real-world applications. This highlights the importance of industry partnerships, open-access data repositories, and guidance from domain experts in the learning process.

6. Perceived Impact on Agricultural Productivity

- Strongly Agree: 2
- Agree: 3
- Neutral: 2
- Disagree: 1

Discussion:
Approximately 71% of students believe analytics can enhance productivity in rural farming. This supports the premise of analytics-driven transformation. The neutral and disagree responses suggest some students may not fully grasp the linkage, emphasizing the need for clearer demonstrations of impact through field-based case studies.

7. Perception of Faculty Integration of Agri-Analytics Examples

- Agree/Strongly Agree: 5
- Neutral/Disagree: 5

Discussion:
While half the students feel that faculty effectively incorporate agriculture-related examples into analytics teaching, the other half remain unconvinced. This indicates a significant opportunity for faculty development, curriculum enrichment, and guest lectures from Agri-tech professionals.

8. Satisfaction with Institutional Support for Sector-Specific Applications

- Very Satisfied: 2
- Satisfied: 4
- Neutral: 3
- Unsatisfied: 1

Discussion:
60% of students expressed satisfaction with current support, indicating a good start. However, 40% of respondents were either neutral or unsatisfied, signalling the need for better access to tools, research opportunities, and domain-specific mentorship. Institutional collaboration with Agri-startups or government schemes can fill this gap.

9. Participation in Agriculture-Focused Analytics Projects or Events

- Yes: 7
- No: 3

Discussion:
A strong participation rate shows enthusiasm among students for sector-specific applications. This also signals potential for scaling interdisciplinary projects involving agriculture, sustainability, and analytics. Those who did not participate may have faced information or accessibility barriers, which should be addressed through early and inclusive outreach.

10. Suggestions for Improvement (from open responses)

Themes Identified:

- Hands-on training with real agricultural datasets
- More case studies and guest sessions on rural analytics
- Introduction of sector-based labs or modules
- Increased exposure to sustainability-linked agri-analytics

CONCULSION

This study explored how business analytics can unlock value in underutilized sectors, specifically focusing on rural and small-scale agriculture. Using a mixed-method approach and a structured survey administered to students specializing in business analytics, the research assessed awareness, practical understanding, perceived benefits, and challenges related to the application of analytics in agricultural settings.

The findings indicate that there is a strong awareness of the role business analytics can play in transforming rural agriculture. Students recognize the potential of data-driven decisions in improving productivity, reducing risks, and promoting sustainable farming practices. With 90% reporting awareness of analytics

in agriculture and a majority expressing willingness to adopt such tools, there is a promising foundation for future integration.

In terms of impact, participants largely agreed that business analytics can enhance agility in farming operations—by enabling timely, informed responses to unpredictable factors like weather, market prices, and pest outbreaks. Similarly, students acknowledged that analytics can support circular economy principles by helping minimize waste, optimize input use, and improve yield efficiency. However, limited exposure to real agri-datasets and lack of hands-on training were cited as barriers, revealing a disconnect between theoretical understanding and practical application.

Despite this potential, several challenges were identified. Nearly half the participants reported insufficient training or unfamiliarity with agricultural-specific tools. These gaps underscore the need to enhance education and practical exposure to sector-specific analytics applications.

Students also provided constructive feedback, such as the need for targeted training programs, collaborations with Agri-tech startups, and integration of sustainability-focused analytics into the curriculum. These suggestions reflect a strong interest in making business analytics more accessible and impactful in rural agricultural domains.

In conclusion, while students recognize the importance of business analytics in revitalizing rural and small-scale agriculture, there remains significant room for growth. Future strategies should emphasize:

- Strengthening exposure to agricultural data and analytics tools
- Offering specialized training and mentorship opportunities
- Linking sustainability goals with analytics-based practices
- Encouraging interdisciplinary collaborations and case studies

By aligning academic programs with practical sector needs and sustainability imperatives, institutions can empower future professionals to bring data-driven innovation to one of the most vital yet underutilized sectors of the economy.

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