Proceedings of the Nigerian Academy of Science – PNgAS. Vol. 17, No 1s, 2024
Official Journal of the Nigerian Academy of Science

https://doi.org/10.57046/JJEG3473

Original Research Article

Harnessing technology for agricultural transformation: A design thinking approach to alleviate Nigeria's food crisis

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Abstract

The design thinking process is a human-centered, iterative methodology that designers use to solve problems and often results in an innovative approach to problem solving. Using a User Centered Design approach by applying the design thinking process, the researchers sought to know: 1. What national challenges were priority for Nigerians and 2. What solutions were best to tackle the problem that had the highest votes. To understand the need assessment, a survey form was designed and disseminated. A total of 406 participated in the poll, with over 70% votes for agriculture as the problem that requires urgent attention in Nigeria. Further research revealed post-harvest loss as a predominant problem in Nigeria's agricultural sector. Key stakeholders in the sectors including farmers and agricultural experts were interviewed to further empathize, understand and redefine the problem. The design thinking process helped to refine the problem statement and identify other problems as well as potential solutions. From the survey, it was clear the majority of Nigerians who participated felt that agriculture and post-harvest loss were high priority needs that required urgent attention. Applying design thinking to prioritize agriculture in Nigeria reveals its power to address complex socio-economic issues effectively. By deeply understanding stakeholders' needs, clearly defining the problem, and iteratively developing and refining solutions, design thinking ensures that interventions in agriculture are not only relevant and impactful but also sustainable and scalable. This approach aligns perfectly with the urgent need for agricultural development in Nigeria to mitigate economic instability and enhance food security.

Keywords: *Food security, post-harvest loss, agriculture, user centered design, design thinking process, human-centered design, iterative methodology*

1.0 INTRODUCTION

Nigeria, the most populous nation in Africa, is confronted with a multitude of complex challenges

https://doi.org/10.57046/JJEG3473

that hinder its socio-economic progress [1, 2]. Over the past three years, the country has grappled with a wide range of issues, spanning from agricultural instability to political unrest, creating an urgent need for innovative solutions [3,4].

Agricultural instability, a critical concern, has witnessed a decline in crop productivity over the last three years. According to the Nigerian Ministry of Agriculture and Rural Development, maize yields have decreased by 12% and rice production by 15% during this period [5]. This decline exacerbates food security concerns and underscores the pressing need for effective interventions in the agricultural sector. Efforts to define and address these problems have been varied and reflect the complexity of the issues at hand. Government agencies, non-governmental organizations, and academic institutions have proposed a range of strategies. These include policy interventions such as subsidy programs and market reforms, as well as grassroots initiatives aimed at capacity-building and knowledge transfer. Technological advancements in precision agriculture and sustainable farming practices have also been promoted as potential solutions.

Despite concerted efforts, a significant gap persists in leveraging design thinking principles to identify and address high-impact problems in Nigeria. Design thinking, as a human-centered approach to problem-solving, emphasizes empathy, ideation, and prototyping. By placing the end-users at the forefront of problem identification and solution generation, design thinking offers a promising avenue for reframing and tackling Nigeria's persistent issues [6]. Design thinking principles have the potential to offer innovative and sustainable solutions to the complex challenges facing Nigeria farmers. By engaging stakeholders in a collaborative and iterative process, design thinking can uncover previously overlooked problems and generate solutions that resonate with the needs and aspirations of the affected communities.

2.0. RELATED WORK

Design thinking can be defined as an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign [7]. Design Thinking consists of five steps namely Empathize, Define, Ideate, Prototype and Test [12]. Empathize covers activities of data collection to understand and observe for users' needs based on the problem. In the define phase, the information gathered during the empathy phase is organized to define the problem. Ideate includes activities of challenging assumptions and suggestions with creative ideas to solve the problem. Prototype involves activities of developing tangible representations to demonstrate creative solutions. Test consists of activities of presenting the prototypes to potential users for feedback [12]. Design Thinking has received wide attention and application in various areas such as business [10, 11], health [10], software Development [8, 9]. Agriculture is now taking a new turn with the advent of smart farming and digital technologies. In order to develop a user-centered solution, it's imperative to use the principles of design thinking.

In the research of [15], the concept of design thinking principles was used to provide a human-centered design to provide insights to guide research and development of technologies in rangelands. Findings from their research shows that the use of design thinking principles can help unlock potential for smart and digital farming. In the work of [16], design thinking was useful in helping farmers to obtain better sowing techniques to improve harvest in a community in Mexico. Their solution leveraged on the use of databases and through the use of design thinking and experiments, their work was able to provide highest nutritional quality and value. In Portugal, following Post-Covid findings that one in three people would experience food insecurity [17] , the

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use of design thinking principles to address this problem was spur [18]. Findings from their research shows that the use of design thinking principles led to city transformation and sustainability, enabled stakeholders to learn from each other and combined theory and practice in a manner that met food needs while reducing environmental impacts. In the research of [18], the design thinking approach was used to engage with farmers, farm advisors and inspectors, research scientists, app developers and national agricultural body in Ireland. Findings from their research revealed that inclusion of multiple stakeholders in developing new farming technology harness the full value of multiple knowledge and expertise.

Though design thinking in Agriculture is spreading fast, it is relatively new or under explored in Africa [19]. Design thinking has been identified as an innovation methodology that encourages out-of-box thinking. Therefore, this study would consider addressing agricultural problems in Nigeria using the principles of design thinking.

3.0 METHODOLOGY

In this specific section, our investigative approach was intricately designed to delve into potential solutions for the multifaceted challenges confronting Nigeria. The foundation of our methodological framework rested upon the application of design thinking principles, a strategic methodology renowned for its efficacy in addressing complex issues, particularly in the realm of food security [20 - 23].

The utilization of design thinking principles played a pivotal role in steering our structured process, from the initial stages of problem identification to the eventual implementation of our impactful project. This approach not only facilitated a comprehensive understanding of the challenges at hand but also guided the meticulous selection of a focal area for our intervention. By integrating the iterative and human-centric nature of design thinking, we navigated through the intricacies of problem-solving, ensuring a nuanced exploration of potential solutions.

The visual representation of our journey through the design thinking process, encapsulating the careful selection of our project focus and the initiation of the initial implementation phase, is illustrated in Figure 1. This visual guide serves as a tangible reflection of our methodological approach, illustrating the systematic progression through the various stages of design thinking that have steered our endeavors towards addressing the pressing challenges faced by Nigeria.

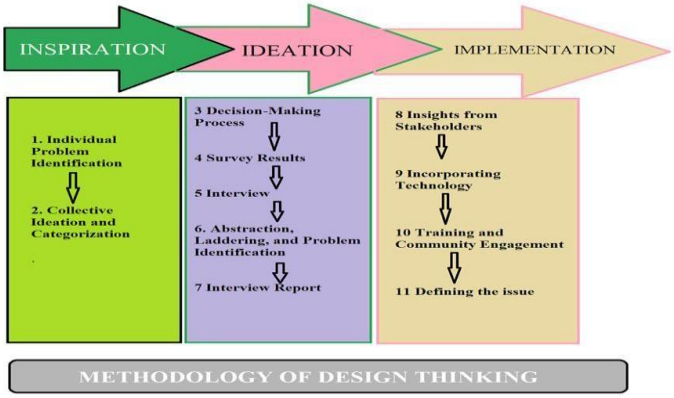

Figure 1: Schematic view of the methodology

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3.1 Individual problem identification

At this stage, each member of the research team was asked to list various problems that require urgent need and solution in Nigeria. This is in line with the principles of design thinking that encourages thinking wide and narrowing down. We compiled the identified problems, totaling 32, and categorized them broadly into agriculture, renewable and alternative energy, recycling, gender inclusion, sustainable cities, and education. The team's diverse expertise and problem identification align with the principles of design thinking, emphasizing the importance of a holistic understanding of challenges. Such interdisciplinary collaboration encouraged the exploration of innovative solutions that can be used to address real-world problems. The user-centric focus and iterative nature of design thinking guided the team in developing impactful and sustainable solutions to the identified challenges.

4.0 RESULT

4.1 Quantitative analysis

Descriptive and inferential analysis were carried out. For descriptive, visual illustrations such as pie-chart, bar graph were used to represent and describe various distributions and responses. In addition, tables were used to show percentage/ratio distributions. For the inferential analysis, relationships between variables will be studied. Microsoft Excel was used to do analysis and data visualization. Simple codes/scripts were written in excel to carry out aggregate computation.

4.2 Participants basic demographics

A total of 406 individuals participated in the needs assessment survey. Among the participants, 65.8% are females, 33.5% are males and 0.7% chose not to reveal their gender. The age group with the highest frequency is 36 - 45 representing 36.7% and age group 66 and above have the lowest frequency representing 2.2%. For a detailed breakdown of the demographic characteristics of the participants, please refer to Table 1.

Table 1: Demographic Information of all participants

Category		Count	Percentage (%)
Gender	Male	136	36.5
	Female	267	65.8
	Prefer not to say	3	2.2
Age	18 – 25	58	14.3
	26 – 35	91	22.4
	36 – 45	149	36.7
	46 – 65	99	24.4
	66+	9	2.2

4.3 Descriptive analysis of the responses

According to [24, 25], a problem is evaluated as addressing the socio-economic issue of a country or nation if it is

1) key or urgent need with global relevance

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2) impactful with a wide reach
3) has a quick or finite execution time with good scalability
4) Investment worthy with minimal money and scalable

4.3.1 Urgent need

As identified in section 3, four problems or themes which centered around Mental Health of Women and Girls, Cyber Security for marginalized groups, Digital Literacy for Teachers and Food Insecurity and Insurgency in Agriculture emanated from the design thinking process. These 4 themes were then presented to the participants. The probe was "Which of the following problems in Nigeria do you think needs the most urgent attention?". Interestingly, 71.7% of them confirmed that Agriculture was most pressing, 17.2% chose mental health issues amongst females, 7.4% chose digital literacy and 3.7% chose cybersecurity. The pie chart for this is represented in figure 2.

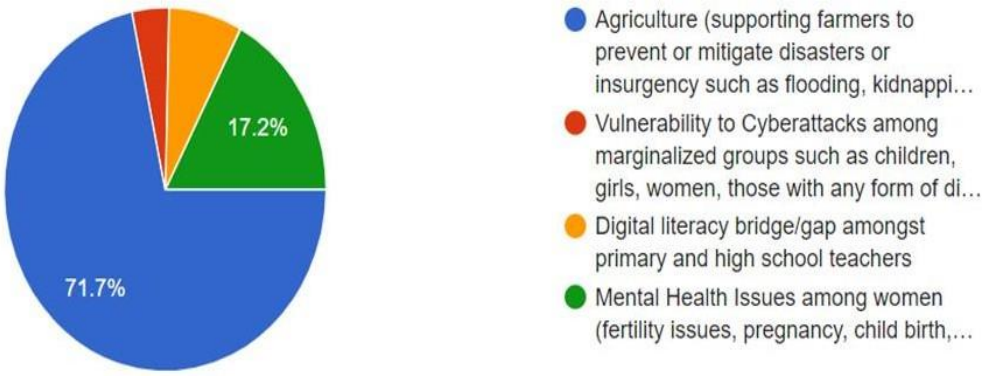

Figure 2: Diagrammatic representation of the rating of the problems according to their immediate need

On further analysis using aggregate functions and queries, we tried to understand how gender influences the responses of people's choice. Interestingly, themes like female's mental health issues and their vulnerability to cyber-attacks did not receive high choices by women. Agriculture has the highest vote by females with 68.5% of them choosing it while other themes on female gender had 26.6%. Figure 2 summarizes the votes of problems that need attention according to gender. We further analyzed based on age -group, interestingly all age groups gave high votes to agriculture problems with 83.8% of those in age group 46 -65 as the highest and that of age group, 35 - 45 as the lowest with 64.6%. Mental health has a vote of between 10% and 22% across the various age groups. Digital literacy and Cyber Vulnerability had somewhat similar votes ranging between 1% and 12%. Table 3 summarizes the responses of participants grouped by their age group.

Reflecting on the further analysis, we can deduce that the choice of agriculture that needs attention is a choice of all age groups and gender. We further saw that topics that seemed male or youth inclined like Cyberattacks or female inclined like Mental Health of females were not voted highly by those groups. This implies that the choice of agriculture is indeed chosen unbiased.

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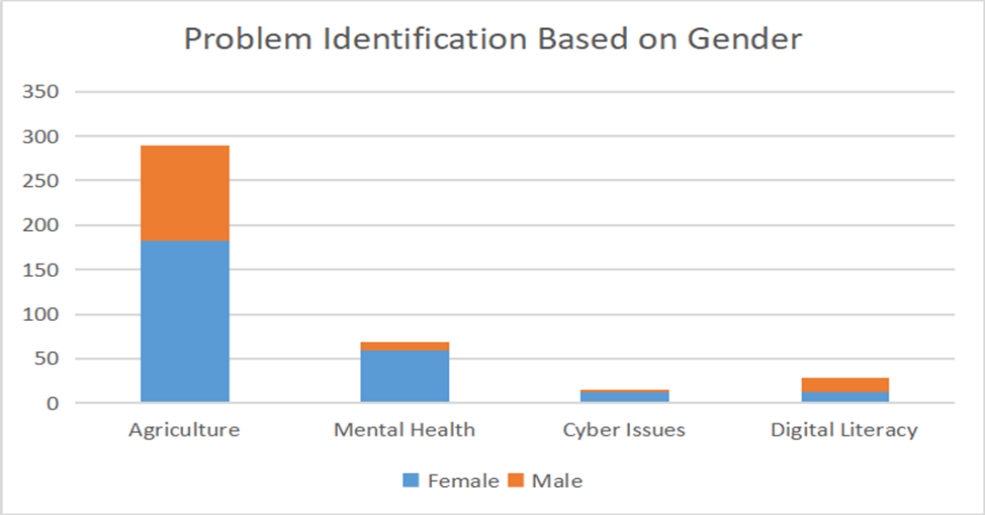

Figure 3: Graph distribution for problem identification based on gender

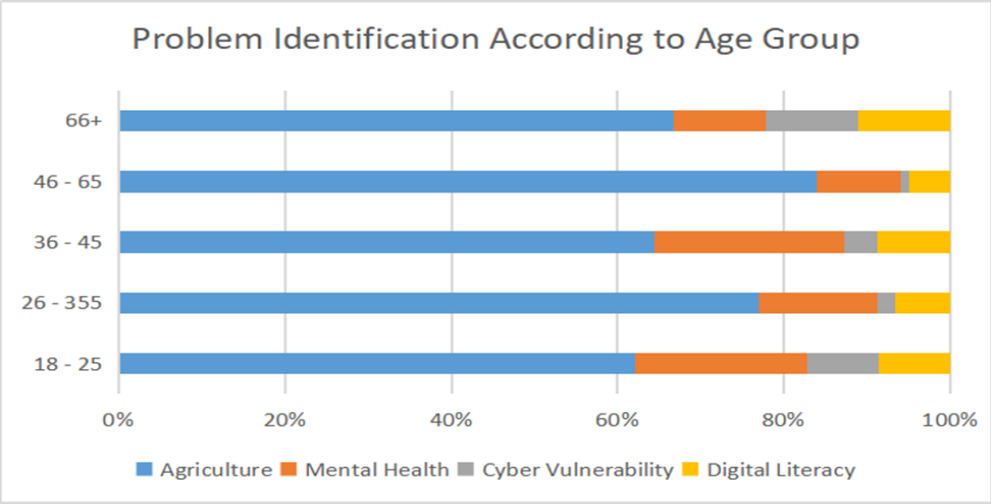

Figure 4: Graph distribution for problem identification based on age group

4.3.2 Why agriculture?

We were keen on why over 70% of the respondents chose agriculture, so we further probed and listed options for participants to choose from. The options given are:

1. A means to alleviate Nigeria from poverty
2. A silent killer problem that Nigerians don't want to talk about
3. Global reputation of Nigeria on the issue
4. Personal Experience or that of a close family member or friend
5. The Economic Situation of Nigeria

In addition, we provided an open-ended text-field/options for participants to freely express the reasons they chose agriculture and what precise problems to solve under agriculture. From figure 5, it's obvious that option 5, which is the economic situation of Nigeria, has the highest number of respondents for why agriculture should be a top priority problem to be solved compared to other issues - mental health, digital literacy and cyber-attack. This isn't too surprising as the economic

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situation of the country has greatly deteriorated with a dollar exchange going for as high as over 1000 Naira for just 1 USD. In addition, with a lot of industries closing down, the oil production declining and food scarcity on high, it's obvious that the citizens would want other options that can lift the economic situation of the nation.

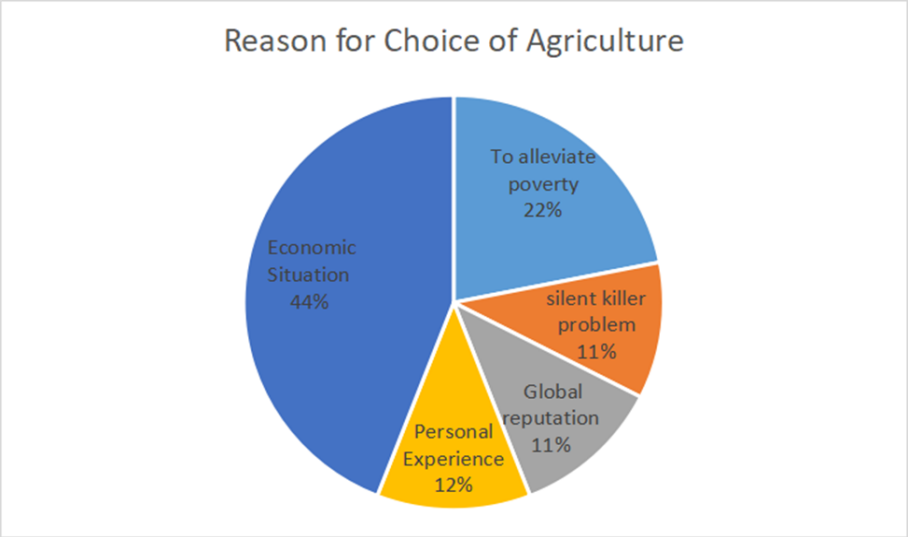

Figure 5: Reasons on choice for agriculture

4.3.3 Investment worthiness

We further probed the participants to indicate which of the 4 themes/problems: Agriculture, Digital Literacy, Mental Health and Cyber Attack is worth investing into under a budget of 1000USD. This is important to ensure an identified problem can be solved within a short time frame and minimal budget in such a manner that it would have maximal impact. From previous research, a number of projects have been abandoned in Africa because of lack of proper planning or budgeting or financial issues [26 - 27]. As a result, it is expedient that a problem is voted as worth investment to yield tangible results, before venturing into it.

When considering investment under a limited budget (1000USD), agriculture was again deemed the worthiest area:

- **Feasibility and impact**: 67% of respondents believed that agriculture is a viable sector to invest in, capable of yielding tangible results within a short time frame and with minimal budget. This is close to the vote in figure 1 where 71% identified agriculture as the problem that needs urgent attention. This further confirms that not only is agriculture a pain-point but it's also worth investing into.

- **Scalability**: With 74% believing that solutions in agriculture can reach a wide audience, it is clear that investment in this sector is seen as both impactful and scalable.

- **Quick execution**: 44.5% felt that agricultural problems could be addressed quickly, making it an attractive option for immediate intervention.

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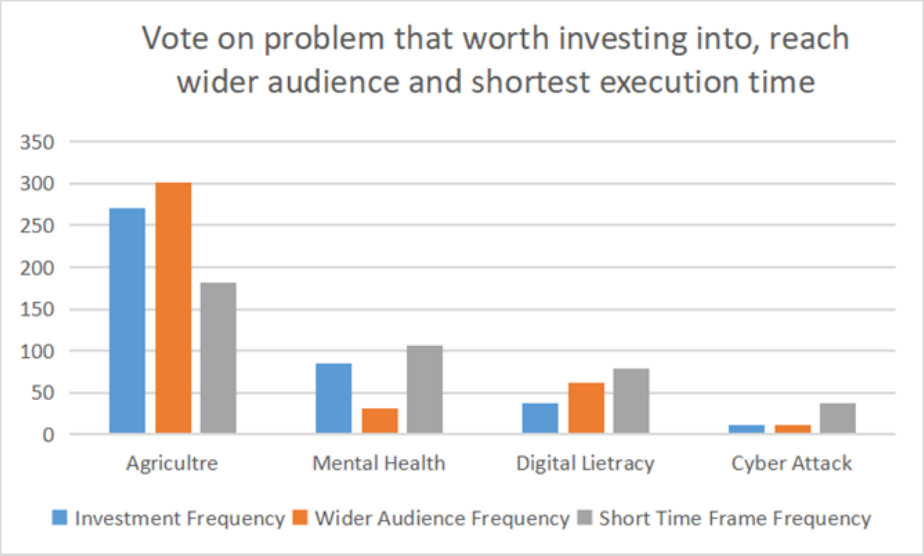

Figure 6: Representation of problem that can be solved within short-time frame, worths investment into and will reach wider audience

4.4 Discussion

Design thinking is a human-centered approach to innovation that integrates the needs of people, the possibilities of technology, and the requirements for business success. Its application involves several stages: empathize, define, ideate, prototype, and test [12]. When applied in this research to the socio-economic issues in Nigeria, design thinking provides a structured framework to address complex problems, such as the prioritization of agriculture over other issues.

The initial stage of design thinking involves empathizing with the stakeholders to gain deep insights into their needs and challenges. The survey conducted can be seen as part of this empathizing process. From the survey results and further analysis, it is evident that agriculture is perceived as the most pressing issue in Nigeria. The overwhelming majority (71.7%) of participants identified agriculture as requiring the most urgent attention, significantly outpacing other issues like mental health of women and girls (17.2%), digital literacy for teachers (7.4%), and cybersecurity for marginalized groups (3.7%).

- **Reason for prioritizing agriculture**:
  - **Economic situation**: The economic instability in Nigeria, with the Naira's significant depreciation against the US dollar and the decline in oil production, underscores the urgency for a sustainable and resilient sector like agriculture to alleviate poverty and enhance food security.
  - **Wide impact**: The agricultural sector's potential to uplift the economic condition of a large segment of the population makes it a vital area for intervention. This aligns with the criteria that an issue must be impactful with a wide reach.

Interestingly, the choice of agriculture transcends gender and age groups, indicating a broad consensus on its importance. Despite agriculture receiving 68.5% of the votes from women, issues directly affecting them, such as mental health and cybersecurity, were not prioritized by female respondents. This suggests a collective recognition of agriculture's critical role over more gender-specific concerns. Across all age groups, agriculture consistently received high votes.

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4.4.1 Implications for policy and development

The findings indicate that any socio-economic development strategy for Nigeria should prioritize agriculture due to its broad-based support and potential for high impact. Policymakers and development organizations should:

- **Focus resources**: Allocate resources towards agricultural development, ensuring that projects are well-planned and budgeted to avoid the common pitfall of project abandonment.
- **Inclusive strategies**: Develop inclusive strategies that consider the diverse needs and perspectives of different gender and age groups to ensure widespread support and success.
- **Integrated approaches**: Combine efforts in agriculture with initiatives in mental health, digital literacy, and cybersecurity to create a holistic development framework.

By addressing the urgent need in agriculture, Nigeria can tackle its economic challenges, improve food security, and pave the way for broader socio-economic development.

5.0 CONCLUSION

In conclusion, the findings from the design thinking process and subsequent analysis reveal a clear consensus among participants that agriculture is the most pressing issue requiring urgent attention in Nigeria. Most respondents, comprising various age groups and genders, emphasized the critical need to address challenges related to food insecurity and insurgency in agriculture.

Notably, the analysis also highlighted interesting trends in the participants' preferences based on gender and age groups. While agriculture received overwhelming support across all demographics, topics such as mental health issues among females and cybersecurity for marginalized groups did not resonate as strongly, especially among women. This suggests a nuanced perspective on societal priorities, with a broad recognition of the urgency in addressing agricultural concerns. The unbiased nature of the choice for agriculture is a noteworthy observation, indicating that the perceived urgency transcends gender and age-group considerations. This collective response underscores the widespread recognition of the impact that addressing agricultural challenges can have on the overall well-being and stability of the community.

As the next steps unfold, the data-driven insights gleaned from this analysis can guide the implementation of targeted initiatives to address the identified challenges in agriculture.The inclusive and unanimous support for addressing agricultural issues sets a strong foundation for collaborative efforts, emphasizing the importance of a holistic approach to achieving sustainable development in Nigeria.

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