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Investigating the Impact of the Central Agricultural Research Institute's (CARI) Agricultural Extension Services on the Productivity and Livelihoods of Farmers in Bong County, Liberia, from 2013 to 2017

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Abstract:- In Liberia, a country where agriculture plays a pivotal role in socio-economic development and food security, the effectiveness of agricultural extension services remains crucial yet underexplored, especially in the context of transitioning from subsistence to commercial agriculture. This study focuses on assessing the Central Agricultural Research Institute's (CARI) agricultural extension services' impact on the agricultural productivity and livelihoods of farmers in Suakoko, Jorquelleh, and Yealliquelleh districts of Bong County, from 2013 to 2017. The objectives were to evaluate the accessibility and adoption of agricultural innovations disseminated by CARI and analyze the effectiveness of its extension delivery methods. Employing a mixed-methods approach, the research yielded significant findings: 54.1% of respondents were male, indicating a gender disparity in agricultural engagement. The adoption of new technologies and practices was varied, with 43.3% of farmers reporting access to new fertilizer application methods as the most prominent innovation provided by CARI. Despite the extension efforts, 68.8% of farmers did not receive visits from CARI agents, and a considerable 50% reported no access to new innovations or technologies. The study also highlighted a distinct preference for learning through demonstrations (73.7%) and meetings (25%), underscoring the demand for practical and interactive extension services.

Keywords and Definitions:-

- **Agricultural Extension Services:** A series of educational activities and support services designed to assist farmers and rural communities in improving agricultural productivity, income, and livelihoods through the dissemination of practical information on farming techniques, innovations, and technology.
- **Commercial Agriculture:** The production of crops and livestock for sale in the market, often involving large-scale operations, advanced technologies, and significant capital investment, in contrast to subsistence farming which is primarily for family consumption.
- **Innovations in Agriculture:** New methods, ideas, products, or services implemented to improve efficiency, productivity, sustainability, or profitability in the agricultural sector. This includes the adoption of new farming techniques, technologies (e.g., improved seed varieties, pest management systems), and practices (e.g., conservation agriculture).
- **Technology Adoption:** The process by which farmers and agricultural practitioners start to use new technologies or innovations. Adoption can be influenced by several factors, including access to information, perceived benefits, and socio-economic and environmental conditions.
- **Productivity:** In the context of agriculture, productivity refers to the output (e.g., crop yield) per unit of input (e.g., land, labor, capital). Higher productivity indicates more efficient use of resources.
- **Sustainable Practices:** Farming methods and practices that maintain the balance between meeting human needs and preserving the environment so that these needs can be met not only in the present but also for future generations. This includes practices like soil conservation, water management, and organic farming.
- **Gender Disparity:** The difference in treatment or outcomes between men and women. In the context of this study, it refers to the unequal access to agricultural extension services, resources, and opportunities in farming activities.
- **Socio-Economic Development:** The process of social and economic improvement or growth in a community or region. In the context of this study, it pertains to how advancements in agricultural practices and productivity can contribute to improving the quality of life and economic status of individuals and communities.
- **Livelihoods:** The means and activities through which people obtain necessities for living. In rural agricultural contexts, livelihoods are often directly related to farming and related activities.
- **Integrated Pest Management (IPM):** A sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks.

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I. INTRODUCTION

Agriculture is pivotal to Liberia's socio-economic development, food security, and poverty alleviation, with the majority of its rural population relying on it for livelihood. The transition from subsistence to commercial agriculture, driven by technological advancements, market expansion, and policy reforms, presents both opportunities and challenges for farmers (Green et al., 2005; Bardara, 2000). Agricultural extension services, therefore, are crucial in enabling farmers to access innovative technologies and information, thereby improving agricultural productivity and sustainability. These services have evolved from mere technology transfer to facilitating learning and addressing broader issues such as marketing, resource conservation, and food safety (USAID, 2002).

A. Background of the Study

Despite Liberia's agricultural potential, various factors, including infertile soils, low rainfall, pests, limited resources, and infrastructural deficits, hinder its agricultural productivity. Additionally, the impacts of civil unrest and the Ebola outbreak have devastated the agricultural sector and its extension services. The Central Agricultural Research Institute (CARI), located in Suakoko, Bong County, plays a pivotal role in research and extension, aiming to disseminate new technologies and innovations to improve production and productivity. However, the effectiveness of these services in addressing the challenges faced by farmers in Bong County's districts of Suakoko, Jorquelleh, and Yealliquelleh remains uncertain (Mcmilian and Sanders, 2001; Nyensuah, 2016).

B. Statement of the Problem

Liberia's agriculture faces multifaceted challenges exacerbated by war, disease outbreaks, and climate change vulnerabilities. The destruction of extension services and infrastructure has led to significant gaps in farmer knowledge and technology adoption, resulting in low agricultural productivity. The study aims to investigate the impact of CARI's agricultural extension services on farmers in the selected districts of Bong County, focusing on the efficiency and effectiveness of these services in overcoming the myriad challenges to improve agricultural outcomes.

C. Objectives of the Study

To assess the impact of the Central Agricultural Research Institute (CARI) agricultural extension services on the agricultural productivity and livelihoods of farmers in Suakoko, Jorquelleh, and Yealliquelleh districts of Bong County from 2013 to 2017.

➢ *Specific Objectives*

- Evaluate the Accessibility and Adoption of Agricultural Innovations: To determine the extent to which farmers in the targeted districts have access to and adopt agricultural innovations and technologies disseminated through CARI's extension services.
- Analyze the Effectiveness of Extension Delivery Methods: To analyze the effectiveness of various extension delivery methods used by CARI in reaching and impacting farmers in the study areas, considering the diverse agricultural practices and challenges specific to each district.

II. LITERATURE REVIEW

The evolution of agricultural extension services has transitioned from traditional top-down technology transfer models to more participatory and integrated approaches, addressing the complex challenges faced by today's farmers. Early forms of agricultural extension can be traced back to practices in ancient China and later developments in Europe and North America, where agricultural schools and experimental farms played pivotal roles in disseminating agricultural knowledge and practices. For instance, Philipp Emanuel von Fellenberg, in the early 19th century, established agricultural schools and an experimental farm in Switzerland, significantly contributing to agricultural education and the spread of innovative farming techniques (Jones & Garforth, 1997).

Modern agricultural extension services began to take shape in response to agricultural crises, such as the potato blight in Europe in the mid-19th century. The British government's initiative to appoint itinerant lecturers to educate small farmers on improving cultivation practices marked the beginning of organized extension services. This model expanded throughout Europe and the United States, evolving over time to include a more formal educational component for farmers and their families (Jones & Garforth, 1997).

The shift towards participatory approaches in agricultural extension services reflects the need to engage farmers actively in the learning process, recognizing their knowledge and experiences. Such approaches aim to foster a two-way exchange of information between farmers and extension providers, improving the relevance and effectiveness of the services offered. Innovative models, like the integrated, climate-resilient field school methodology discussed by Osumba et al. (2021), exemplify this evolution by combining elements of Farmers' Field Schools, Climate Field Schools, Climate-Smart Agriculture, and indigenous technical knowledge into a comprehensive package that addresses the multifaceted challenges of climate change and agricultural sustainability (Osumba et al., 2021).

The history and development of agricultural extension services underscore the importance of adapting extension methodologies to the changing needs and circumstances of the agricultural sector. From the early dissemination of agricultural knowledge by itinerant teachers and experimental farms to the modern, integrated, and participatory approaches, agricultural extension has continually evolved to better serve the needs of farmers, enhance agricultural productivity, and promote sustainability.

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A. Historical Development of Agricultural Extension Services

The historical development of agricultural extension services has seen a significant shift towards participatory methods and the integration of Information and Communication Technologies (ICTs), enhancing the effectiveness and reach of these services. This evolution is underscored by a move from traditional top-down technology transfer approaches to more inclusive and interactive models, leveraging technology to bridge gaps between research and practical application in farming.

Participatory methods in agricultural extension emphasize the active involvement of farmers in the learning process, fostering a two-way exchange of knowledge between extension agents and farmers. This approach not only enhances the relevance and applicability of the information shared but also empowers farmers by recognizing their valuable insights and experiences. The integration of ICTs further amplifies the impact of these participatory approaches by overcoming geographical barriers, enabling timely access to information, and facilitating wider dissemination of agricultural knowledge and innovations.

A scoping review highlighted the crucial role of agricultural extension programs in disseminating knowledge, empowering farmers, and driving agricultural development. The review points out the necessity of leveraging technology to enhance the delivery of extension programs, noting that technology applications can lower communication costs, improve smallholder market access, and household welfare, leading to improved farming practices, increased productivity, and enhanced agricultural outcomes (Xu, Adeyemi, Catalan, et al., 2023).

Furthermore, the integration of ICT in agricultural extension has been identified as a transformative force, offering innovative tools and applications that revolutionize farming practices, optimize resource utilization, and address sustainability challenges. The application of technology in agricultural extension has been explored from two distinct yet interconnected perspectives: the use of technology as a factor of production and as a means of enhancing knowledge transfer and skills development through educational technology (ET) (Xu, Adeyemi, Catalan, et al., 2023).

However, it's essential to acknowledge that despite the potential benefits of integrating ET and agricultural technology in extension services, comprehensive reviews of practical outcomes are still lacking. This gap underscores the need for further research to explore the effectiveness and impact of these integrated approaches in agricultural extension services (Xu, Adeyemi, Catalan, et al., 2023).

In sum, the shift towards participatory methods and the integration of ICTs in agricultural extension represents a significant advancement in how agricultural knowledge is disseminated and adopted. These developments promise to enhance the efficiency, accessibility, and impact of extension services, contributing to sustainable agricultural practices and improved livelihoods for farmers worldwide.

B. The Role of Extension Services in Agricultural Productivity

Agricultural extension services play a crucial role in enhancing agricultural productivity, sustainability, and the socio-economic well-being of rural communities. These services bridge the gap between agricultural research and practice by disseminating knowledge, introducing innovative farming techniques, and providing tailored advice to farmers. The role of extension services in agricultural productivity encompasses several key areas:

- *Knowledge Dissemination and Skill Development*

Extension services are fundamental in transferring cutting-edge agricultural research and practices from scientists to farmers. Through training sessions, demonstrations, and field visits, extension agents equip farmers with the knowledge and skills needed to adopt modern agricultural techniques, manage pests and diseases more effectively, and improve crop and livestock management practices (Xu, Adeyemi, Landaverde, et al., 2023).

- *Technology Transfer and Adoption*

The integration of new technologies, including both hard technologies (e.g., improved seed varieties, machinery, and irrigation systems) and soft technologies (e.g., crop management strategies, soil conservation methods), is facilitated by extension services. They play a pivotal role in demonstrating the benefits of these technologies, encouraging their adoption, and providing support to overcome any barriers to their effective use (Xu, Adeyemi, Landaverde, et al., 2023).

- *Enhancing Market Access and Linkages*

Extension services assist farmers in understanding and accessing markets, including providing information on market demand, quality standards, and prices. By linking farmers with markets, extension agents help to ensure that farmers receive fair prices for their produce and can make informed decisions about what crops to plant and when to sell (Xu, Adeyemi, Landaverde, et al., 2023).

- *Promoting Sustainable Farming Practices*

Sustainability is a critical concern in modern agriculture. Extension services are at the forefront of promoting practices that balance productivity with environmental conservation. This includes the introduction of integrated pest management (IPM), conservation agriculture, and climate-smart agriculture techniques that help to mitigate the effects of climate change while enhancing soil health and biodiversity (Xu, Adeyemi, Landaverde, et al., 2023).

- *Social and Economic Empowerment*

Beyond technical advice, extension services can play a transformative role in the social and economic empowerment of farming communities. This includes promoting gender equality by targeting and empowering women farmers, facilitating access to credit and financial services, and supporting farmer groups and cooperatives to strengthen their bargaining power and social networks (Xu, Adeyemi, Landaverde, et al., 2023).

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➢ *Adaptation to Climate Change*

Extension services are crucial in helping farmers adapt to the challenges posed by climate change. This includes disseminating knowledge on climate-resilient crop varieties, water-saving irrigation techniques, and practices to reduce greenhouse gas emissions.

Agricultural extension services are vital for improving agricultural productivity, fostering sustainable practices, and enhancing the livelihoods of rural communities. By serving as a conduit for the flow of information and support between researchers and farmers, extension agents ensure that agricultural innovations are effectively translated into practice, leading to improved food security, economic growth, and environmental sustainability.

C. Adoption of Agricultural Innovations

The adoption of agricultural innovations is a complex process influenced by various socio-economic, institutional, and individual factors. Studies in this field aim to identify and understand the dynamics that affect farmers' decisions to adopt new technologies and practices disseminated through extension services. Key variables influencing adoption include farmer education, access to credit, and the role of social networks.

➢ *Farmer Education*

Education plays a critical role in the adoption of agricultural innovations. More educated farmers are generally more likely to understand and adopt new technologies and practices. A study by Adesina and Baidu-Forson (1995) found that the education level of the farmer significantly influences the decision to adopt new agricultural technologies. Educated farmers are better able to process and evaluate the information received from extension services, leading to higher adoption rates (Adesina & Baidu-Forson, 1995).

➢ *Access to Credit*

Access to credit is another crucial factor influencing the adoption of agricultural innovations. Credit availability enables farmers to invest in new technologies and inputs required for improved agricultural practices. A study by Feder et al. (1985) highlights that access to credit facilitates the adoption of new agricultural technologies by easing liquidity constraints (Feder et al., 1985). However, the same study also points out that the terms and conditions attached to credit, such as interest rates and repayment schedules, can affect adoption rates.

D. Role of Social Networks

Social networks, including informal exchanges of information among farmers, play a significant role in the diffusion and adoption of agricultural innovations. Conley and Conley & Udry (2001) investigated the role of social learning in the adoption of new agricultural technologies and found that farmers are more likely to adopt new practices if they observe successful adoption among their peers (Conley & Udry, 2001). Social networks act as channels for the dissemination of knowledge and experiences, influencing farmers' perceptions and decisions regarding new technologies.

➢ *Other Influential Factors*

In addition to the primary factors mentioned, several other variables can influence the adoption of agricultural innovations. These include:

- Perceived benefits: Farmers' perception of the potential benefits and profitability of an innovation can significantly impact their willingness to adopt it.
- Land tenure security: Farmers who own their land or have secure tenure are more likely to invest in long-term improvements, including the adoption of new technologies.
- Extension services: The quality, frequency, and relevance of the information provided by extension services are critical in influencing adoption. Effective extension programs that tailor their messages to the local context and needs of farmers can significantly enhance adoption rates.

The adoption of agricultural innovations is crucial for improving productivity, sustainability, and livelihoods in rural communities. Understanding the factors that influence adoption can help policymakers, extension workers, and researchers design more effective strategies for disseminating agricultural innovations and encouraging their widespread adoption.

III. METHODOLOGY

This study employs a mixed-methods approach to assess the impact of agricultural extension services, integrating both quantitative and qualitative research strategies. In the quantitative phase, we used a structured questionnaire that targeted key indicators like technology adoption rates, and service accessibility, using stratified random sampling for diverse farmer representation across the three districts. Data collection involved direct interviews or questionnaires, with statistical software applied for data analysis, focusing on descriptive statistics. Qualitatively, focus group discussions, in-depth interviews, and observations dive into the nuanced impacts of extension services, examining farmer satisfaction, perceived benefits, and adoption barriers. This approach allowed for a comprehensive analysis, enriching the quantitative findings with qualitative depth. Ethical considerations ensure participant rights and data integrity, while potential research limitations acknowledge biases and methodological challenges.

A. Population and Sample size calculation:

In the context described, EPI Info, a statistical software designed for public health professionals to conduct epidemiological research, including sample size calculations, was utilized to determine the necessary sample size for a population survey across three districts. Let's break down the explanation based on the provided parameters and results:

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➢ *Parameters Set in EPI Info:*

Total Population Size: 640 individuals in the area of interest.

- Number of Clusters (Districts): 3, implying the survey would be conducted in three distinct geographic areas.
- Expected Frequency: 50%, indicating the anticipated proportion of the population displaying the characteristic or outcome of interest. This value is often chosen for maximum variability to ensure the sample size is sufficient to estimate the proportion accurately.
- Margin of Error: 0.05 (or 5%), which reflects the maximum expected difference between the sample estimate and the actual population parameter. A smaller margin of error requires a larger sample size for the same level of confidence.
- Design Effect: 1, a factor that adjusts for the increase in variance that occurs when a study uses a complex design like clustering rather than simple random sampling. A design effect of 1 suggests that the clustering does not increase the variance beyond what would be expected with simple random sampling, which is often an optimistic assumption in clustered designs.

B. Calculation and Result:

Given these parameters, EPI Info calculated that 80 participants needed to be randomly selected from each of the three clusters (districts) to achieve the desired level of precision for the survey's estimates. This calculation accounts for the design of the survey, expected frequency of the outcome of interest, and the margin of error, while assuming no additional variance due to the clustered design (design effect = 1).

C. Sample Size Determination:

By multiplying the number of clusters (3) by the number of participants to be selected from each cluster (80), the total sample size was determined to be 240 participants. This means that, to achieve the survey objectives with the specified parameters, 240 individuals should be randomly selected across the three districts.

D. Explanation:

The calculation is based on the need to ensure that the survey can accurately estimate a parameter (in this case, a frequency of 50%) with a given level of confidence and precision across a specified population, taking into account the survey's clustered design. By choosing 80 participants per cluster, the study aimed to gather enough data to reliably estimate the expected frequency within a 5% margin of error, even when considering the potential complexities introduced by conducting the survey across different geographic areas.

This approach ensures that the sample is representative of the population across the three districts, allowing for reliable and generalizable findings within the defined margin of error and confidence level. The use of clusters can help manage logistical and cost constraints while still providing meaningful data for analysis.

Using EPI Info for sample size calculation of a population survey and descriptive survey the following parameters were reached. Total population size was 640. Number of clusters was 3 districts, expected frequency of 50% and a margin of error of 0.05 with a design effect of 1. The results showed those 80 participants were randomly selected from each cluster (district). Therefore, 3 cluster multiplied by 80 gave 240 as the sample size.

IV. RESULTS AND DISCUSSIONS

Table 1: Distribution of Gender and Age Range

Gender	**Male 142 (54.1%)**	**Female 98 (40.8%)**	
Age Range		41-50	50 above
20-30	85 (35%)	43 (17.3%)	24 (10%)
31-40	89 (37.1%)		

This distribution has implications for agricultural extension services and their effectiveness in reaching and benefiting different segments of the farming community.

➢ *Key Observations:*

- Gender Distribution: The data indicates a higher number of male farmers (54.1%) compared to female farmers (40.8%). This gender distribution is reflective of broader trends in agricultural sectors in many regions, where farming is predominantly male-oriented due to various socio-economic and cultural factors.
- Age Range Distribution: The age distribution shows a significant portion of the farming community is relatively young, with 72.1% of respondents being under the age of 40. This suggests a youthful farming population that might be more open to adopting new technologies and innovations introduced by agricultural extension services.

➢ *Comparative Analysis:*

- When comparing these findings with other studies on agricultural extension services' impact, several themes emerge:
- Gender and Extension Services: The gender disparity in access to and utilization of agricultural extension services is a well-documented challenge. Studies have shown that female farmers often have less access to agricultural extension services due to factors such as cultural norms, responsibilities at home, and less ownership of land and resources (Aduwo et al., 2019). The higher number of male participants in extension programs could reflect these underlying issues.

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- Age and Adoption of Innovations: The relatively young age of farmers in the study is promising for the adoption of new agricultural technologies and practices. Younger farmers are often more willing to experiment with innovative farming techniques and may be more receptive to the changes suggested by extension services. This is consistent with findings from other regions where the youth's involvement in farming correlates with higher rates of technology adoption (Rahman & Connor, 2022).

➢ *Implications for Extension Services:*

- Tailored Approach: There's a need for agricultural extension services to tailor their approach to address the specific needs and constraints of both male and female farmers. This includes considering the best times and methods to reach female farmers and designing programs that are inclusive and accessible to all genders.
- Leveraging Youth: The young demographic represents a significant opportunity for driving agricultural innovation and sustainability. Extension services could focus on leveraging this potential by providing youth-focused training programs that emphasize modern agricultural techniques, digital agriculture, and entrepreneurship in farming.
- Continuous Learning and Adaptation: As shown in the Bangladesh and Ghana/Zambia studies, the impact of extension services can vary significantly based on how they are delivered and the circumstances of the recipients. Continuous monitoring and adaptation of extension methods based on feedback from farmers can help improve their effectiveness.

In conclusion, the gender and age data from Bong County, Liberia, provides valuable insights into the demographic makeup of the farming community, highlighting the importance of targeted and inclusive extension services. Comparing these findings with similar studies underscores common challenges and opportunities in enhancing the effectiveness of agricultural extension services across different regions.

Table 2: Marital Status and Educational Level of Farmers

Married	**Single 91(37.9%)**	**Divorced 19 (7,9%**	**Separate 10 (4.2%)**	**Widow 12 (5%)**	**Widower 8 (3.3%)**	**Married 100 (41.7%)**		
Edu. level	No formal 67 (27.9%)	Primary 52 (21.7%)	Secondary 28 (11.7%)	Dropout 43 (18%)	High sch 32 (13.3%)	Voca.Sch 14 (5.8%)	College 2 (0.8%)	University 2 (0.8%)

The marital status and educational level of farmers have a profound impact on agricultural innovation and productivity. Studies indicate that married farmers, especially women, face distinct challenges and opportunities in the agricultural sector. Married women, in particular, can innovate successfully provided they are in collaborative relationships with their husbands. This collaboration can mitigate some gender-specific constraints related to socio-cultural forces that otherwise reduce agricultural productivity and limit their ability to ensure production. Additionally, marital status influences land ownership and control over production decisions and expenditures, with single women more likely to own land but facing struggles to obtain resources due to customary norms (Badstue et al., 2020).

The level of education among farmers also plays a critical role in their capacity to adopt agricultural innovations. Educated farmers are more likely to engage in agricultural innovation, suggesting that education, along with marital status and family responsibilities, entices people towards innovation in agriculture. This is particularly true for smallholder women, whose capacity to innovate in agriculture is positively influenced by their marital status. The education and empowerment of women farmers are essential for fostering innovation and achieving sustainable agricultural development (Badstue et al., 2020).

These insights underscore the importance of considering socio-demographic factors such as marital status and educational level in the development and implementation of agricultural policies and programs. Addressing these factors can enhance the effectiveness of agricultural extension services, improve access to resources and innovative technologies, and ultimately contribute to sustainable agricultural development and food security.

Table 3: Distribution of CARI Extension Services Outcome Result

CARI Extension Services outcome result	**Respondents**	**Percentages**
High Production	13	54
Low Production	131	54.6
Moderate Production	64	26
No Production	32	13.3
Total	240	100

The findings from the CARI Extension Services outcome result, showing the distribution of farmers' production levels, indicate varied impacts of extension services on farm productivity. To contextualize these findings, we can look into existing studies on the impact of agricultural extension services.

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A study analyzing the effects of ACDEP extension programs in Northern Ghana found no significant difference in maize yields between participants and non-participants of the agricultural extension program. However, there was a 20% difference in income from maize in favor of the participants, which was significant. This suggests that while extension services may not always lead to higher yields, they can contribute to increased farm income, possibly through better market linkages. The total household income and per capita income were significantly higher for participating households, indicating that extension services can have a broader positive impact on farmers' economic well-being (Danso-Abbeam et al., 2018).

The variation in the effectiveness of extension services can be attributed to several factors, including the nature of the extension activities, the local agricultural context, and the specific challenges faced by farmers in different regions. For instance, extension services that focus on linking farmers to markets or provide specific knowledge on crop management could lead to different outcomes in terms of production and income.

The general literature on agricultural extension services supports the idea that these services can play a crucial role in improving farm productivity and income, by disseminating knowledge on best practices, new technologies, and market opportunities. However, the impact varies significantly based on how the services are implemented, the local context, and the specific needs and capabilities of the farmers involved (Orivel, 1981).

The findings from the CARI Extension Services outcome, showing a relatively high percentage of farmers experiencing low production despite extension services, underscore the need for a nuanced understanding of the conditions under which these services can be most effective. It points to the importance of tailoring extension services to the specific needs of the farmers and ensuring that these services are part of a broader strategy to support farmers, which may include access to credit, inputs, and market information.

In summary, while agricultural extension services have the potential to significantly impact farm productivity and income, the outcomes depend heavily on various factors including the design and focus of the extension services, local agricultural conditions, and the socio-economic characteristics of the farmer households. This underscores the complexity of agricultural development efforts and the need for tailored, context-specific approaches to extension services.

Table 4: CARI's Extension Methods Used

CARI Extension Methods Used	Respondents	Percentages
Mass Media	176	73.3
Group Discussion	31	12.9
Individual discussion	33	13.8
Total	240	100

The data presented on the CARI extension methods used and the distribution of respondents by method highlight the predominant reliance on mass media (73.3%) for agricultural extension, followed by individual discussion (13.8%) and group discussion (12.9%). This distribution raises several points for discussion and comparison with existing literature on agricultural extension services.

➢ *Implications:*

- Reach and Scalability: Mass media's dominance as an extension method underscores its potential for broad reach and scalability. It's an efficient way to disseminate information to a large audience, which is crucial in regions with many farmers and limited extension workers. However, the effectiveness of mass media can vary based on the quality of the content, accessibility for the target audience, and the extent to which the information meets the farmers' needs.
- Personalization and Interaction: The relatively lower percentages for individual (13.8%) and group discussions (12.9%) suggest a lesser focus on methods that allow for personalization and interaction. These methods are crucial for addressing specific concerns, providing tailored advice, and facilitating a two-way exchange of information between farmers and extension workers. They are particularly effective in complex agricultural decisions that require back-and-forth communication, such as pest management or the adoption of new technologies.
- Integration of Methods: The effective integration of various extension methods could enhance the overall impact of extension services. Combining mass media with interactive methods like group and individual discussions can provide both the efficiency of broad reach and the effectiveness of personalized support. This approach can help bridge the gap between general information dissemination and the application of knowledge to specific local contexts.

➢ *Comparison with Previous Studies:*

Research indicates that the effectiveness of agricultural extension methods varies widely, influenced by factors such as the nature of the information being disseminated, the socio-economic characteristics of the farmer population, and the agricultural context. For example, a study on the impact of extension services in Ethiopia found that face-to-face extension methods, including group and individual discussions, were more effective in improving agricultural productivity compared to non-personal methods. This was attributed to the interactive nature of these methods, which allowed for a more nuanced understanding and application of

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the agricultural advice provided (Danso-Abbeam et al., 2018).

In support of the notion that mass media can significantly impact agricultural extension by rapidly increasing awareness and knowledge among farmers, especially in areas with a high ratio of farmers to extension agents, a study highlights the importance of mass media in the agricultural extension and development process. Mass media, encompassing print, broadcast, and digital media, is crucial for disseminating information that helps farmers make knowledgeable decisions regarding agricultural activities. The study points out that broadcast media, such as radio and television, are particularly effective in reaching farmers with vital information and knowledge. However, it also notes the limitations of printed materials in educating farmers with limited literacy, suggesting that information intended for a broad audience may not address the specific needs of every farmer across different communities (Anyanwu & Udoh, 2022).

Additionally, a World Bank document discusses the role of mass media in supporting basic education and agricultural extension. It emphasizes the extension and educational services' goals, underlining mass media's potential to enhance the reach and effectiveness of these services (Orivel, 1981).

These findings align with the broader literature, suggesting that mass media campaigns, when effectively implemented, can play a significant role in improving agricultural knowledge and practices. They offer an efficient way to reach a vast number of farmers, complementing more personalized extension methods like individual and group discussions. The effectiveness of mass media in agricultural extension underscores the need for a multi-channel extension strategy that combines the broad reach of mass media with the depth of personal interactions to address the diverse needs of the farming community.

The findings from the CARI extension methods used align with global trends indicating a shift towards more scalable and cost-effective extension approaches, such as mass media. However, the literature emphasizes the importance of complementing these broad-reach methods with more interactive and personalized approaches to address complex issues and facilitate the practical application of knowledge.

In summary, while mass media provides an efficient way to reach a large audience, the effectiveness of agricultural extension services is significantly enhanced by incorporating interactive methods that allow for personalization and two-way communication. The integration of various extension methods, tailored to the specific needs and contexts of the target population, is crucial for maximizing the impact of agricultural extension services on farm productivity and livelihoods.

Table 5: Farmers most Preferred CARI Extension Service Method

Farmers Most Preferred CARI Extension Service Method	Respondents	Percentage
Poster	0	0
Public Address	3	1.3
Leaflet	0	0
Letter	0	0
Meeting	60	25
Demonstration	177	73.7
Total	240	100

The data on farmers' most preferred CARI Extension Service Methods reveals a significant preference for demonstrations, with 73.7% (177 respondents) favoring this method, followed by meetings at 25% (60 respondents). Other methods such as public address, posters, leaflets, and letters received minimal to no preference, with public address garnering only 1.3% (3 respondents) and the others receiving 0%.

➢ *Implications:*

- Practical Learning Preference: The strong preference for demonstrations indicates that farmers value practical, hands-on learning experiences. Demonstrations allow them to see firsthand how to implement new techniques or technologies, which can increase their confidence in adopting these practices on their own farms.
- Social Learning Environment: The preference for meetings suggests that farmers also value the social aspect of learning, where they can share experiences, ask questions, and learn from each other in a group setting. This aligns with adult learning theories that emphasize the importance of social interaction and experiential learning.
- Limited Engagement with Print and Broadcast Media: The negligible preference for posters, leaflets, and letters suggests that these methods may not be as effective in engaging farmers or conveying complex agricultural information. This could be due to literacy barriers, the passive nature of these communication methods, or both.
- Need for Interactive Extension Services: The data underscores the importance of interactive and engaging extension methods that facilitate active learning and participation among farmers. Extension services may need to focus more on these methods to effectively reach and impact the farming community.

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➢ *Comparison*

The preference for demonstration methods and meetings among farmers, as indicated by the findings, reflects broader trends observed in agricultural extension studies. Demonstrations, being highly favored at 73.7%, align with the principle that farmers prefer to see firsthand how new ideas work and the impact they can have on crop production. This method provides tangible, visible proof of the benefits of new practices, which is crucial for convincing farmers to adopt these practices themselves. The emphasis on demonstrations is supported by research indicating that practical demonstrations are an invaluable method in extension work, particularly for farmers who may not easily absorb information through reading or lectures. Demonstrations allow farmers to observe directly the differences between recommended new crop practices and traditional ones, highlighting the simplicity and effectiveness of new methods in a way that written materials cannot (Oakley & Garforth, 1983).

Meetings, preferred by 25% of respondents, underscore the importance of social learning environments where farmers can share experiences, ask questions, and learn from each other. The structure and conduct of meetings, whether formal or informal, play a significant role in facilitating effective communication and decision-making among community members. Smaller meetings, in particular, are noted for their ability to meet specific needs and foster productive discussions, emphasizing the value of interaction and participation in the learning process (Oakley & Garforth, 1983).

Comparatively, a study on improved agricultural extension approaches in Tunisia explored the design of innovative and cost-effective technology transfer systems. This research highlighted the need for extension methods to be locally emergent, based on experimentation, learning, and adaptation to both prevailing and evolving conditions. The study suggested that extension should be demand-driven, with extension staff receiving appropriate training to ensure services meet end-users' needs effectively. It also pointed to the use of partnerships and information and communication technologies (ICTs) as means to enhance the efficiency of resource use in extension services (Dhehibi et al., 2022).

These findings, both from the preference data and the study in Tunisia, underline the critical need for agricultural extension services to focus on interactive, engaging methods that facilitate active learning and participation among farmers. Demonstrations and meetings serve as effective platforms for such engagement, offering practical insights and fostering a community-based approach to learning and innovation in agriculture.

Table 6: CARI's Agent Visit to field

CARI agent Visit to Field	Respondents	Percentage
Yes	82	39.2
No	158	68.8
Total	240	100

The findings indicate a significant portion of farmers (68.8%) did not receive visits from CARI agents, suggesting potential gaps in extension service delivery. Previous studies, such as one assessing the impact of agricultural extension on farmers in Bangladesh, highlight the importance of extension service attributes like frequency of contact and provider type (government or private) on outcomes like fertilizer use, yield, and profit. Frequent extension contacts were associated with better outcomes, including less overuse of urea fertilizer and higher crop yields and profits, indicating the quality and frequency of extension interactions can significantly influence farming practices and outcomes (Rahman & Connor, 2022)

Table 7: New Innovations and Technology Provided by CARI

New Innovations and technology provided by CARI	Respondents	Percentages
Fertilizer Application	104	43.3
Compost making	3	1.3
Pesticide application	7	2.9
IMP method	6	2.5
None	120	50
Total	240	100

The key findings from the data on new innovations and technology provided by CARI reveal a notable emphasis on fertilizer application, with a significant portion of respondents (43.3%) identifying it as a new innovation or technology they have accessed. This interest in fertilizer application might be reflective of the critical role fertilizers play in enhancing crop yields and soil fertility. However, the distribution also highlights a relatively low engagement with other sustainable practices like compost making, pesticide application, and Integrated Pest Management (IMP) methods, alongside a substantial percentage of respondents (50%) indicating no access to new innovations or technologies.

Comparing these findings with recent studies offers valuable insights. For instance, a study on the adoption of fertilizer application in agriculture from Ethiopia explored the complex relationship between technology adoption and market participation, emphasizing that success in agricultural

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growth through the adoption of modern agricultural technologies primarily depends on market opportunities. The study underscores the importance of promoting smallholders' technology adoption to enhance productivity and enable broader market participation, with a positive impact of inorganic fertilizer on market participation of Kenyan maize suppliers also highlighted (Tesfay, 2020).

Another relevant study conducted in Bangladesh focused on Boro rice farmers' adoption decisions regarding recommended fertilizer doses. This study pointed out the long-term inefficiencies within the agricultural sector despite previous productivity gains from fertilizer subsidies. It underlined a significant shift towards sustainable intensification methods to adjust fertilizer use, aiming to reduce environmental degradation while enhancing agricultural practices. The emphasis was on understanding the factors influencing farmers towards balanced nutrient application and promoting sustainable agriculture practices (Sunny et al., 2022).

These comparative studies highlight the global trend towards not just enhancing agricultural productivity through modern technologies like fertilizer application but also the growing recognition of sustainable practices. The focus on balanced nutrient application, efficient use of resources, and sustainable intensification reflects a broader shift in agricultural practices towards sustainability. In contrast, the high percentage of "None" responses in the CARI data could signal barriers to access, adoption, or awareness of these technologies and innovations. Bridging these gaps could be crucial for integrating more farmers into sustainable agricultural practices, aligning with global trends towards environmental sustainability and increased productivity.

V. CONCLUSION

The study concludes that CARI's agricultural extension services, while foundational in addressing the technological and informational needs of farmers, exhibit disparities in effectiveness and reach. The data suggests a higher engagement and preference for demonstrative and meeting-based extension methods among farmers, indicating the critical role of interactive and practical learning in agricultural innovation adoption. However, a considerable portion of the population reported not receiving any new innovations or technologies, pointing to gaps in extension service delivery. Furthermore, the gender and age distribution of the study population hints at underlying socio-economic and cultural dynamics influencing access to and the impact of extension services.

RECOMMENDATIONS

Enhance Interactive Extension Methods: CARI should prioritize more engaging, practical, and interactive extension approaches like demonstrations and meetings, which have shown higher preference and effectiveness among farmers. These methods should be designed to cater to the diverse needs of the farming community, including gender and age-specific considerations.

- Improve Service Delivery and Reach: Efforts should be intensified to bridge the current gaps in extension service delivery, ensuring that more farmers receive visits from CARI agents. A targeted approach, focusing on underrepresented and hard-to-reach segments, could enhance the overall effectiveness of the services.
- Focus on Sustainable Agricultural Practices: Given the global shift towards sustainable agriculture, CARI's extension services should incorporate more training and resources on sustainable practices like compost making, Integrated Pest Management (IMP) methods, and efficient pesticide application. This shift is crucial for aligning Liberia's agricultural sector with global sustainability trends and ensuring long-term environmental and economic viability.
- Leverage Technology and Innovation: To overcome the challenges of scale and reach, incorporating ICT and other innovative tools in extension services could provide a scalable solution. Digital platforms can complement traditional extension methods, offering wider accessibility and tailored agricultural advisories.
- Strengthen Feedback Mechanisms: Implementing robust feedback mechanisms to gather insights directly from farmers about their needs, preferences, and challenges can guide the continuous improvement of extension services. This approach can help CARI to adapt and evolve its strategies in real-time, ensuring they remain relevant and impactful.

By implementing these recommendations, CARI can significantly enhance the efficiency, reach, and impact of its agricultural extension services, ultimately contributing to improved agricultural productivity, sustainability, and the socio-economic well-being of farmers in Bong County, Liberia.

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