Improving Agricultural REsilience to SAlinity Through DEvelopment and Promotion of Pro-poor Technologies and Management Strategies in Selected Countries of Sub-Saharan Africa (RESADE project)

General Introduction

Project description: The RESADE project is being implemented in 6 sub-Saharan countries, namely The Gambia, Togo, Liberia, Sierra Leonne, Mozambique, and Botswana. The project aims to improve the productivity of smallholder farmers in salinity-affected areas by introducing and promoting adapted climate-smart technologies and crops with high tolerance to salinity and drought. Furthermore, the project seeks to develop value chains around salt-tolerant cropping systems and to build the capacity of farmers and extension workers in salinity-resilient and climate-smart agriculture. The project has used best practice hubs and farmer-field schools approaches to disseminate technologies, increase awareness, and empower smallholder farmers with requisite knowledge on technologies to overcome salinity challenges and increase crop yields. The technologies explored include the use of salt-tolerant crop varieties, the use of soil amendments, irrigation methods to reduce salinity through leaching, and soil and moisture conservation and management practices. Foods and recipes based on crops tested at the BPH were also developed in a bid to create value chains for the crops. Community-based seed production and processing units were established and strengthened through training and provision of the necessary equipment to enable them to produce good quality seeds of the recommended crop and forage varieties for dissemination to farmers in the targeted and other areas. Farmer's cooperatives were established or identified, in order to create economies of scale in production, harvesting, aggregation, processing, and marketing, as well as to enhance farmers' collective bargaining power.

Analysis purpose: The project has been running since 2019 and farmers were engaged in project activities at the BPH from the onset. We collected data to evaluate the adoption of the promoted technologies by farmers. The purpose of this analysis is to conduct an analysis of the adopters' surveys and the baseline surveys to evaluate the project's impact.

Dataset: The dataset comprises survey data collected from farmers across various villages in the RESADE project-targeted countries, capturing their demographic details, farming practices, and technology adoption. It includes information on respondents' gender, cooperative membership, total farming area, and yield performance under technology adoption. Key variables focus on the adoption of agricultural technologies such as biochar, foliar micronutrients, Californian irrigation systems, and improved crop management practices. The dataset also documents whether respondents received new crop seeds, the varieties of seeds and quantities received, and the timing of their planting. Additionally, it details the area cultivated under specific technologies and the resulting yields. Comments from respondents provide qualitative insights into their experiences, challenges, and feedback, offering a comprehensive view of farming practices and technology impact in each of the countries of intervention.

Data analysis method: The data were analyzed in STATA using descriptive statistics to summarize key variables and explore overall patterns, as well as differences by gender group. These methods provided insights into data variables distribution, central tendencies, and variability, facilitating a comprehensive understanding of the dataset and gender subgroup characteristics and impacts.

Promoted technologies adoption data analysis by country

I. Country: Togo

1.1. Descriptive analysis

Demographic analysis: In Togo, in total 84 farmers have been surveyed in 4 different villages of the project. The majority of respondents (64.29%) are female, while males account for 35.71%. This suggests significant participation of women in the surveyed farming activities, reflecting their active role in agriculture within these regions. The largest group of respondents is from **Atti Apedokoe** (55.95%) village, followed by **Keke Kope** (25.00%), with **Attite Kopé** and **Betekpo** each contributing 9.52%. This distribution indicates a concentration of respondents in Atti Apedokoe, potentially due to its larger population or greater involvement in the surveyed agricultural activities. All the respondents are part of a cooperative group. Female members outnumber male members in all cooperatives, indicating greater participation of women in these farming groups.

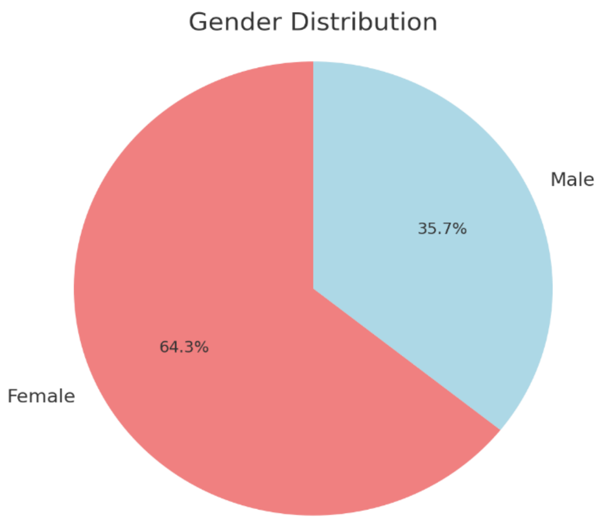

Figure 1.1. Gender distribution

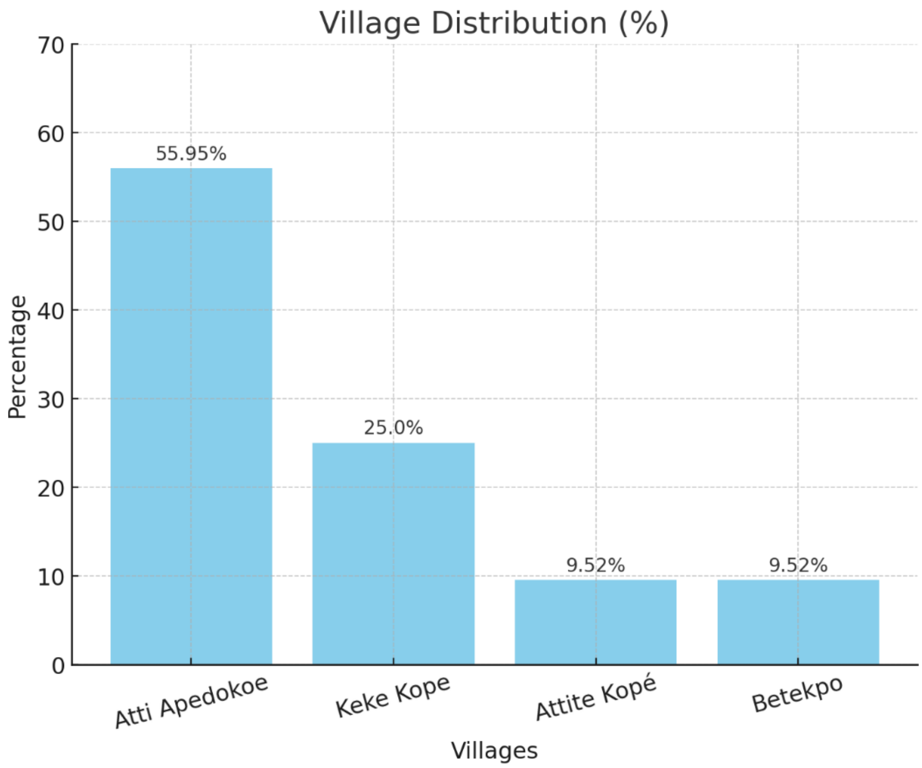

Figure 1.2. Villages distribution

Among cooperatives, the **Cooperative la Main de Dieu** has the highest representation (26.19%), followed by **Novissi Cooperative** (25.00%), and **Dounenyo Cooperative** (22.62%). The **Novilonlon Cooperative** (11.90%) and **Kekeli Cooperative** (14.29%) have fewer respondents. This shows varied participation across cooperatives, with Cooperative la main de Dieu and Novissi Cooperative playing prominent roles. The women's participation is higher in each cooperative. The average farming area is **1.41 hectares**, with a standard deviation of **0.97 hectares**, indicating some variability in land size among respondents. The smallest farm size is **0.375 hectares**, while the largest is **5 hectares**. This range highlights the prevalence of smallholder farming systems in the surveyed population.

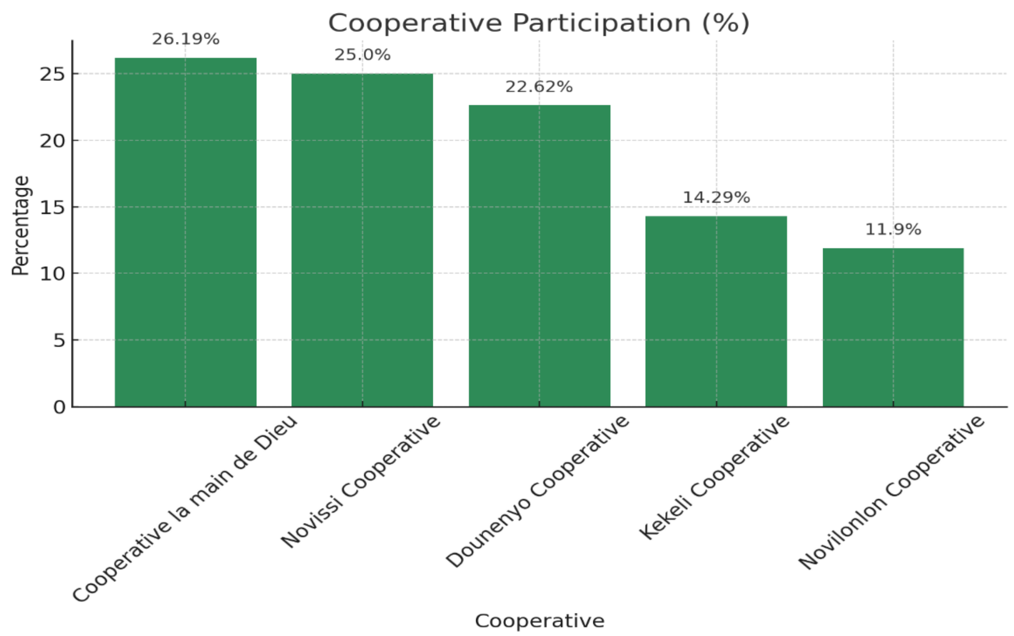

Figure 1.3. Cooperative Participation (%). Shows the proportion of respondents in each cooperative, emphasizing the prominence of Cooperative la main de Dieu and Novissi Cooperative.

1.2. Crop basket

New crop varieties distributed in Togo are Rice, millet, and sorghum. Over half of the respondents (52.38%) reported **not receiving new crop seeds**, pointing to potential gaps in distribution or data collection processes. Addressing these gaps could enhance project reach and effectiveness. Among those who did, **Rice** was the dominant crop (45.24%), with **Millet** and **Sorghum** each received by 1.19% of respondents. Among those who received seeds, **IR 841** was the predominant variety, accounting for **45.24%** of responses. However, 54.76% of respondents reported not receiving any crop variety. Also, the quantities received are very small varying from 0.25 kg to 3 kg. This emphasizes the need for clarity and consistent tracking of distributed seed varieties to ensure effective agricultural support. **15 men** (50%) did not receive any crop seeds, while **15 men** (50%) received **Rice**, making it the only crop distributed to male farmers, apart from no recorded distribution for Millet or Sorghum. Among female respondents, **29 women** (53.70%) did not receive any crop seeds, while **23 women** (42.59%) received **Rice**, indicating rice as the primary distributed crop among female farmers. **1 woman** each received **Millet** and **Sorghum**, highlighting minimal diversity in these crop seed distributions to women.

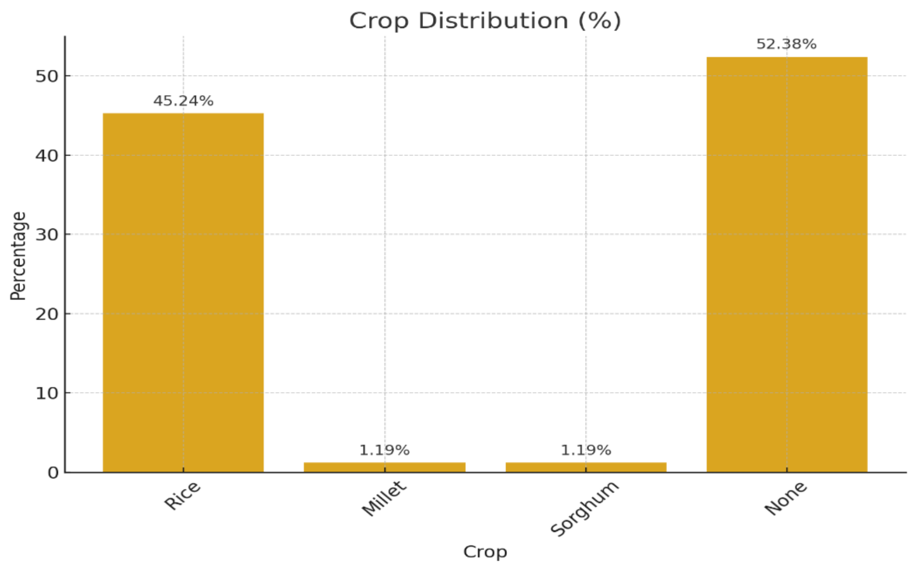

Figure 1.4. Crop Distribution (%). Displays the share of farmers receiving different crop seeds, with rice being the dominant distributed crop and a significant proportion not receiving seeds

1.3. Technologies adopted and surface cultivated

Adoption of Biochar: **23.81%** of respondents reported applying biochar, with the majority (**76.19%**) not using it. Adoption is slightly higher among women (13 women, 24.07%) than men (7 men, 23.33%), indicating relatively even uptake between genders.

Foliar Micronutrients for Fertilization: Only **13.10%** of respondents applied foliar micronutrients, while the vast majority (**86.90%**) did not. Adoption is low across both genders, with 7 women and 4 men using this technology, indicating limited dissemination or perceived relevance of this practice.

Californian Irrigation System: Adoption of Californian irrigation systems is relatively high, with **48.81%** of respondents using it, nearly equal to those not using it (**51.19%**). Women (25) and men (16) show comparable adoption rates, suggesting widespread acceptance of this irrigation technology.

Improved Crop Management Practices: The adoption rate for improved crop management practices is remarkably high, at **95.24%**, showing significant penetration and acceptance of this technology. Both women (52) and men (28) demonstrate high adoption rates, reflecting its accessibility and effectiveness.

Surface: The mean surface area cultivated under one or more technologies is 0.71 hectares, indicating that farmers, on average, apply technologies on a small portion of their total farming area. The standard deviation of 0.39 hectares reflects moderate variability in the surface area cultivated with technologies. The minimum area is 0.0624 hectares, while the maximum is 2 hectares, illustrating a range of adoption scales across respondents. The limited average area suggests that while technologies are being adopted, their application is often constrained to smaller plots, possibly due to resource limitations, risk aversion, or other constraints.

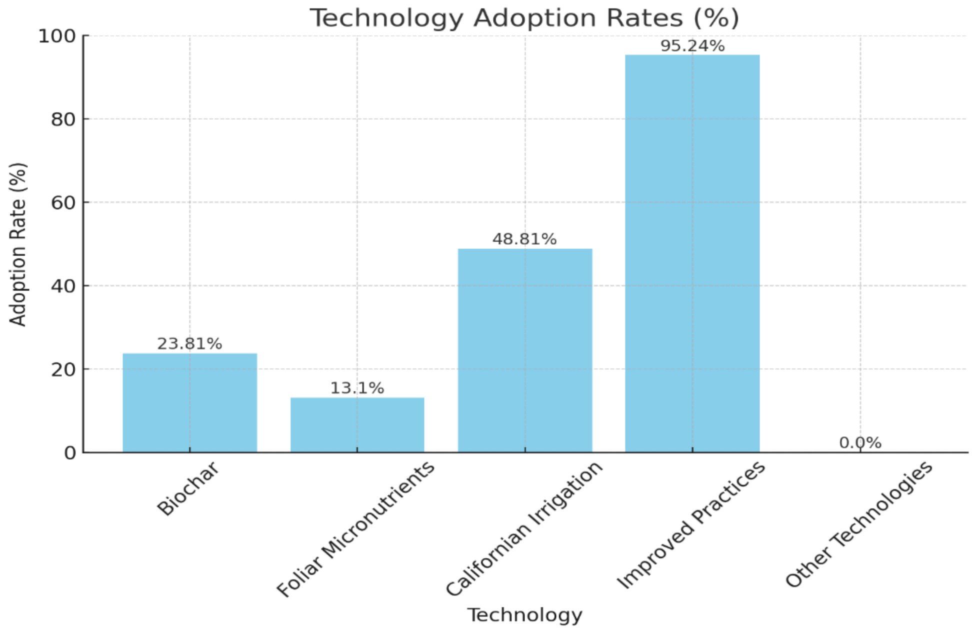

Figure 1.5: Technology Adoption Rates Togo (%)

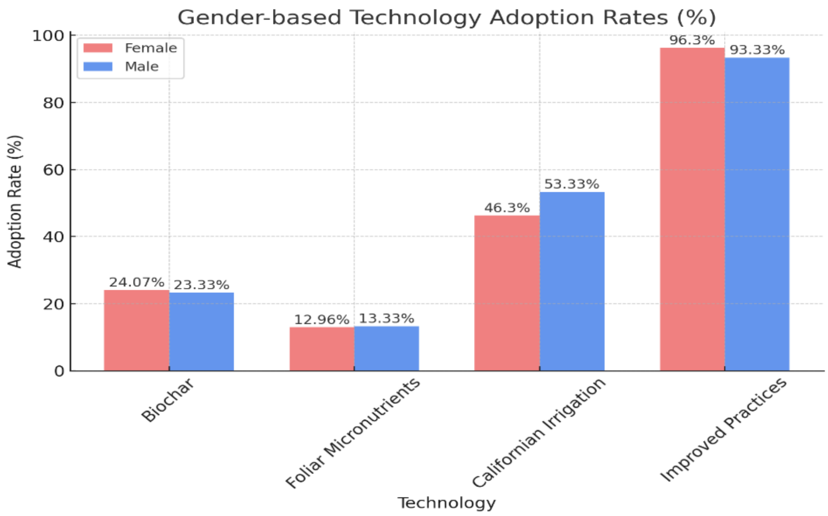

Figure 1.6: Gender-based Technology Adoption Rates Togo (%)

1.4. Crops Cultivated Under Technologies (Other Than Seeds Received) and Yield Analysis (impact on average yield):

Maize dominates as the primary crop cultivated under technologies, accounting for **92.86%** of responses. This suggests maize's importance in the farming systems of the region and its suitability for the applied technologies. Other crops like **Millet** (3.57%), **Sorghum** (2.38%), and **Peanut** (1.19%) are cultivated on a much smaller scale under technologies. This highlights a focus on maize, with limited diversification in crop choice.

According to the average yield harvested, peanut achieves the highest average yield of 2400 kg/ha. This suggests Peanut benefits significantly from the implemented technologies or other favorable conditions. **Maize** follows with a strong average yield of 2086.92 kg/ha, demonstrating its potential as a staple crop supported by these practices. **Millet** shows a moderate yield of 900 kg/ha, indicating scope for improvement through enhanced technological interventions. **Sorghum** records the lowest average yield of 700 kg/ha, highlighting challenges or limited responsiveness to the applied technologies.

The results emphasize the need to tailor technologies further to improve yields for lower-performing crops like Millet and Sorghum while sustaining the success observed in Peanut and Maize.

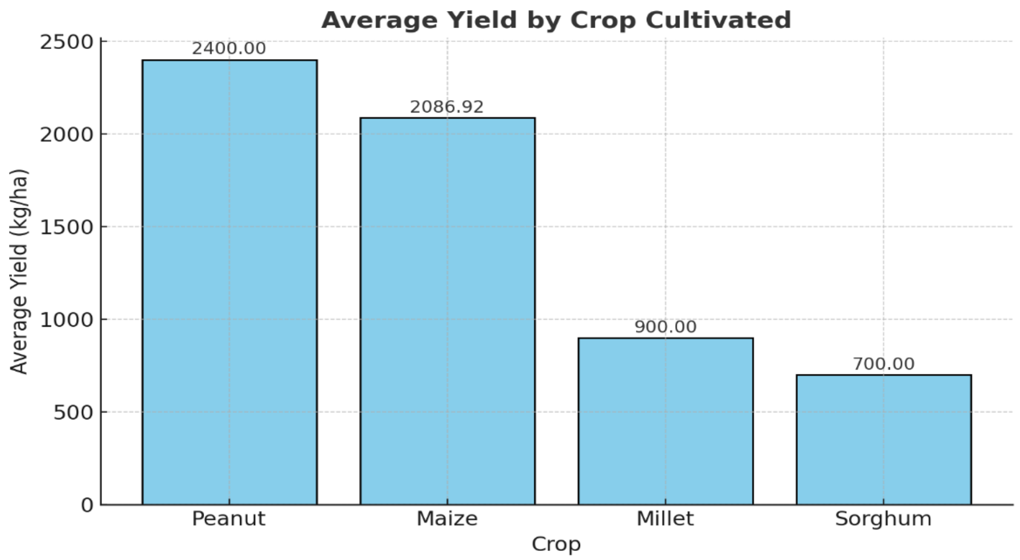

Figure 1.7: The bar chart displays the average yield (in kg/ha) for each crop cultivated

1.5. Technologies impact on crop yield/ yield harvested under different technologies in Togo.

Adoption of technologies like Biochar, Foliar Micronutrients, and Californian Irrigation leads to significant yield improvements.

Biochar impact on average yields: Farmers who adopted Biochar had an average yield of 2202.39 kg/ha, compared to 1932.94 kg/ha for non-adopters. This suggests a positive effect of Biochar adoption on yields.

Foliar Micronutrients impact on average yields: Adopters achieved the highest average yield of 2520 kg/ha, while non-adopters had an average yield of 1918.3 kg/ha. This indicates that Foliar Micronutrients significantly enhance yields.

Californian Irrigation System impact on average yields: Adopters recorded an average yield of 2340.49 kg/ha, compared to 1669.67 kg/ha for non-adopters. The adoption of Californian Irrigation had a notable impact on improving yields, emphasizing its importance in mitigating salinity challenges.

Improved Practices impact on average yields: Adopters achieved an average yield of 1996.45 kg/ha, close to non-adopters at 2010 kg/ha. This suggests that while improved practices contribute to yield improvement, other contextual factors may influence its impact.

This analysis underscores the importance of targeted technology adoption in boosting agricultural productivity and addressing climate and salinity challenges.

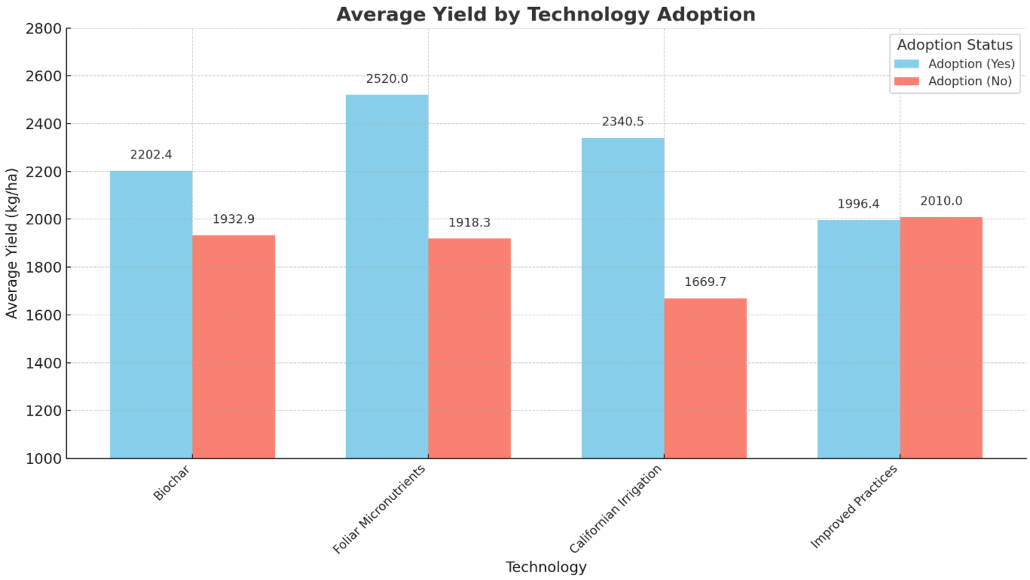

Figure 1.8: Average yield by technology adoption. The bar chart displaying the average yield by technology adoption status

1.6. Interpretation of Results According to the Theory of Change (Togo):

Alignment with Project Activities

1. **Development of Training Packages (Activity 2.4)**:

Farmers in Togo have been trained through Farmer Field Schools (FFSE) on climate-smart technologies, including salt-tolerant crops and soil management practices. The high adoption of improved crop management practices (95.24%) reflects the success of these training packages in imparting knowledge and skills to farmers.

2. **Training of Extension Workers and Farmers (Activity 2.5)**:

The majority of surveyed farmers are part of cooperatives, which have been instrumental in creating economies of scale and facilitating the adoption of technologies. Female farmers outnumber male farmers across all cooperatives, indicating the success of gender-inclusive approaches in FFSE training.

Outputs Achieved

1. **Farmers Trained Through FFSE (3.2.8)**:

The data shows significant adoption of improved practices, irrigation systems (48.81%), and participation in cooperatives, suggesting that the FFSE training has been effective in building capacity among farmers. The higher representation of women (64.29%) further supports the gender-inclusive goal of training at least 50% of women.

2. **Development of Localized Technical Guidelines (3.2.6)**:

The widespread adoption of practices such as improved crop management suggests that these guidelines have been successfully adapted and disseminated to address local salinity and climate challenges.

Outcomes Observed

1. **Adoption of Climate-Smart Technologies**:

The adoption rates indicate positive engagement with project technologies including improved crop management practices (95.24%); Californian irrigation systems (48.81%) and Biochar (23.81%). However, lower adoption of biochar and foliar micronutrients (13.10%) may reflect gaps in resource availability, dissemination, or training effectiveness.

2. **Introduction of Salt-Tolerant Crops**:

The crop distribution data reveals that rice (45.24%), a salt-tolerant crop, was the dominant crop distributed and adopted in Togo. However, limited diversity in crops (millet and sorghum at 1.19% each) and the small quantities of seeds distributed (0.25–3 kg) highlight potential areas for improvement in value chain development and seed availability.

3. **Increased Participation in Cooperatives**:

The establishment and strengthening of cooperatives align with the goal of creating economies of scale. The Cooperative la Main de Dieu and Novissi Cooperative, with the highest memberships (26.19% and 25.00%), have likely played pivotal roles in facilitating access to technologies and markets.

4. **Women's Engagement and Empowerment**:

The majority of respondents in Togo are women (64.29%), reflecting the project's success in engaging women farmers. This aligns with the goal of ensuring 50% women's participation in training and technology adoption. The adoption rate of technologies is higher among women for improved practices and biochar application, and the women's participation in each cooperative is higher.

Key Insights and Recommendations: Togo's outcomes **reflect significant progress toward achieving the regional target of 11,550 farmers adopting new practices**. Scaling interventions, such as expanding crop variety distribution and increasing adoption of underutilized technologies (e.g., biochar), could further enhance impact. Also, continued focus on women's participation and cooperative support will be crucial to sustaining and amplifying these gains across the project's lifetime.

Conclusion

The data from Togo demonstrates significant alignment with the Theory of Change. Farmers have adopted climate-smart practices, particularly improved crop management and irrigation systems, and cooperatives have enhanced collective action. However, further efforts are needed to address gaps in seed distribution and resource availability to maximize the project's impact. To improve the impact of the RESADE project in Togo, training and resources for underutilized technologies like biochar and foliar micronutrients should be expanded to boost adoption and productivity. Women's access to agricultural resources must be strengthened, with technologies tailored to their specific roles in farming. The project should increase engagement in underrepresented villages to ensure equitable access to technologies and training. Promoting crop diversification with salt-tolerant varieties for millet and sorghum will enhance food security and reduce dependency on maize. Additionally, cooperatives should be provided with access to credit, tools, and markets to enhance collective productivity and economic sustainability.

II. Country: Liberia

2.1. Demographic analysis

Gender Distribution: Out of 176 surveyed respondents in Liberia, 75% are female, and 25% are male. This highlights a significant representation of women in the farming activities assessed, showcasing their active involvement in agriculture.

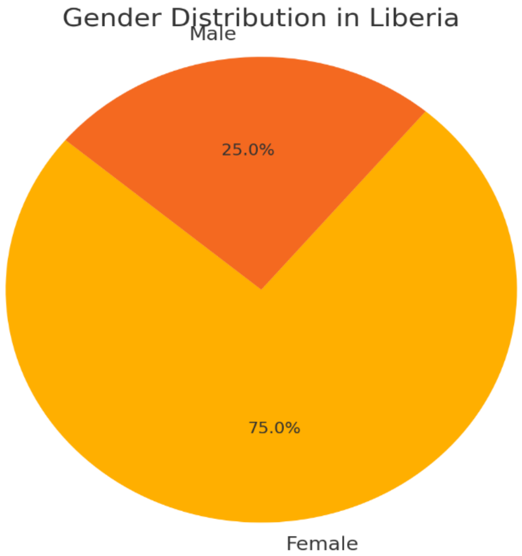

Figure 2.1. Gender distribution in Liberia

Village Representation: Respondents are distributed across 17 villages. The highest representation comes from Dirt Hole (28.98%), followed by Yallayou Town and Korean Farm (each 10.80%). James Henry Town (9.66%) and Compound 1 (7.39%) also have notable participation. Other villages have relatively smaller representation, reflecting varying levels of engagement in the surveyed activities.

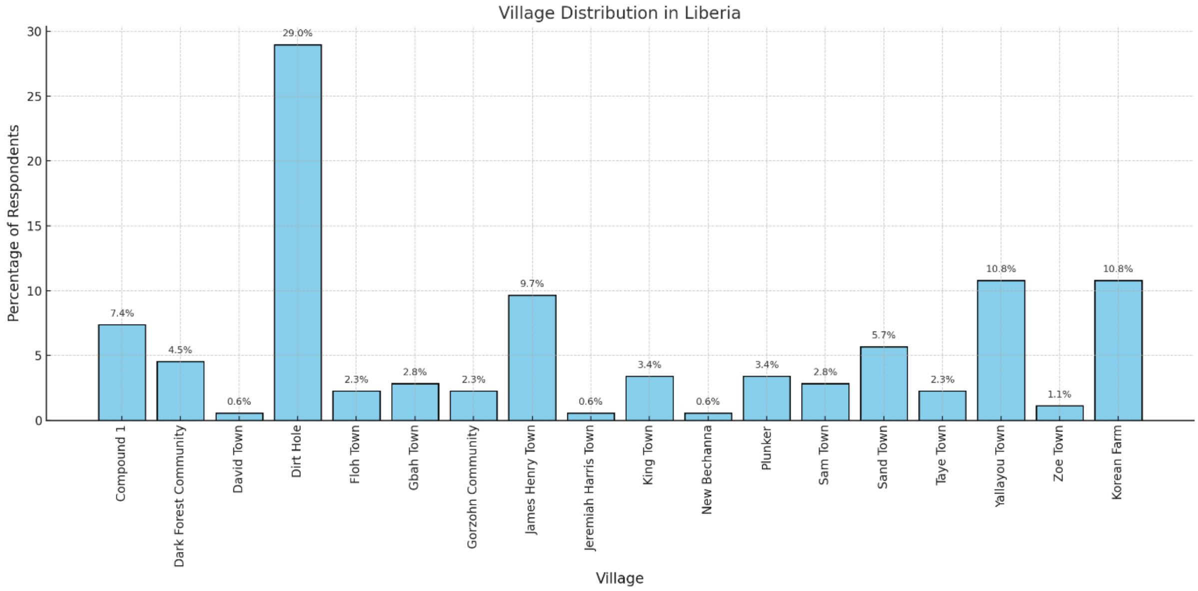

Figure 2.2. Village distribution in Liberia

Cooperative and Individual Participation: Farmers' respondents belong to 6 cooperatives. Out of 168 responses for cooperative or individual participation, "United Women" represents the largest group with 32.14% participation, followed by "Dedo-lay-jay" (23.21%) and individual farmers (17.86%). Smaller cooperatives like "GARMACS" (5.95%) and "Love and Unity" (9.52%) have fewer members, indicating uneven participation across groups. The data indicates high participation from female farmers and strong engagement in cooperatives, particularly women-led groups. The strong participation in cooperatives demonstrates progress in fostering collective action and gender-inclusive economic activities.

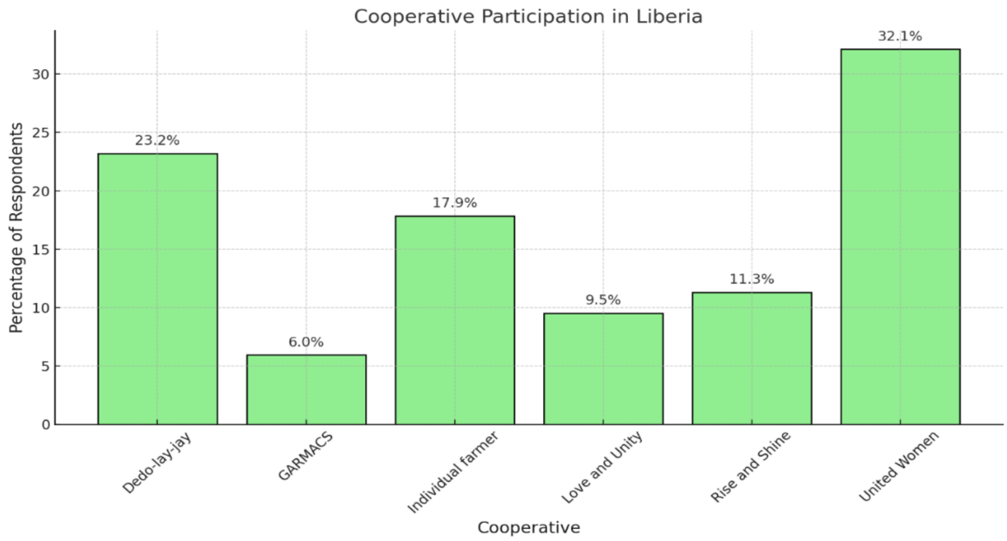

Figure 2.3. Cooperative participation in Liberia

Total Farming Area: Overall, across 175 respondents, the average total farming area is approximately **2.55 hectares**, with a standard deviation of **11.65 hectares**. The wide standard deviation indicates significant variability in the land sizes cultivated by respondents, ranging from a minimum of **0.02 hectares** to a maximum of **140 hectares**. **For gender-based analysis, a**mong 131 female respondents, the average farming area is **1.16 hectares**, with a much smaller standard deviation of **3.74 hectares**.

This suggests that female farmers generally cultivate smaller and more consistent land sizes. The maximum land area cultivated by a female farmer is **40.4 hectares**. On the other hand, among 44 male respondents, the average farming area is **6.70 hectares**, with a standard deviation of **21.99 hectares**. The variability in land sizes for male farmers is significantly higher, with the largest land area being **140 hectares**. These results highlight a notable disparity in the landholding sizes between male and female farmers, with males cultivating much larger areas on average compared to females.

2.2. Crop basket

Crops Distributed: Cowpea (42.86%) is the most widely distributed crop in Liberia, followed by **Sorghum (30.95%)** and **Pearl Millet (18.25%)**, while **Rice (7.94%)** has the lowest distribution. This distribution emphasizes the prioritization of drought- and salinity-tolerant crops, particularly cowpea and sorghum. The limited distribution of rice, a key staple crop, highlights potential gaps in addressing diverse food security needs.

Varieties Distributed: ILRI 9334 (23.02%) and **ILRI 9643 (19.84%)** are the most common varieties distributed, followed by **ICSR-93034 (16.67%)** and **ICSV-700 (14.29%)**. Less prevalent varieties, such as **IP 19586 (10.32%)**, **MC 94 C2 (7.94%)**, **NL-19 (5.56%)**, and **Suakoko 8 (2.38%)**, highlight the need for broader outreach or targeted distribution strategies for these varieties. The variety mix demonstrates efforts to diversify resilience options for farmers but also shows potential underrepresentation of some varieties critical to certain regions.

Quantities Received: The uniform distribution of **0.1 kg per farmer** indicates equitable access but also highlights the limited quantity provided, which may constrain farmers' ability to cultivate crops on larger scales. This limitation could affect adoption and the subsequent impact on productivity.

Implication The crop distribution reflects a strong emphasis on promoting resilient crops like cowpea and sorghum. However, the low distribution of rice and pearl millet calls for more focused efforts to align with diverse food security needs in salinity-affected areas. Limited quantities provided to farmers suggest resource constraints or strategic initial testing. Increasing these quantities will be critical to scaling up adoption and improving the project's reach and impact.

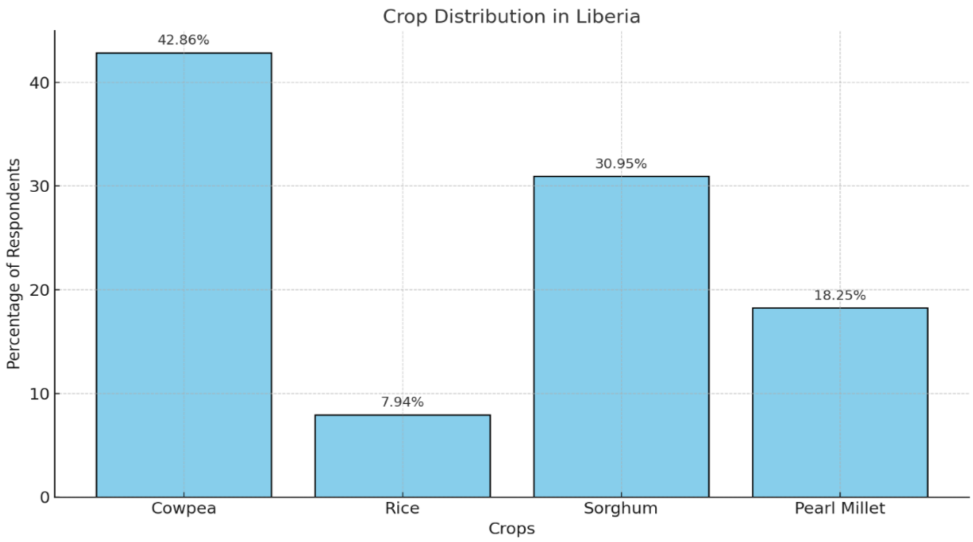

Figure 2.4. Crop distribution in Liberia

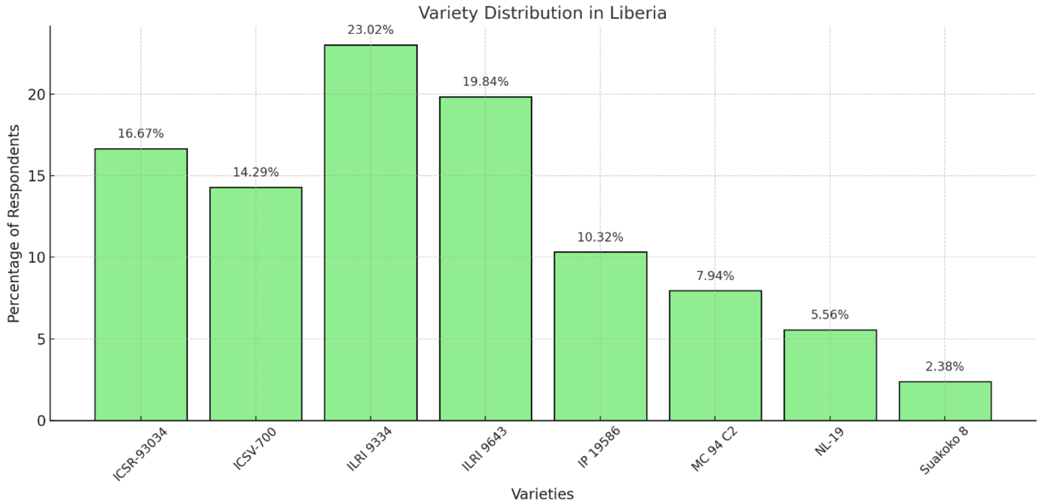

Figure 2.5. Crop variety distribution in Liberia

2.3. Technologies adopted rates and surface cultivated

1. **Biochar is** adopted by **39.20%** of respondents and non-adopted by **60.80%**. The adoption of biochar is moderate, reflecting partial acceptance or limited accessibility among farmers. Regarding the adoption of biochar with gender view, 54 (40.91%) women farmers adopted biochar, while 78 (59.09%) did not. 15 (34.09%) of men farmers adopted biochar, while 29 (65.91%) did not, showing that biochar adoption is slightly higher among female farmers, indicating their engagement with soil enhancement technologies.
2. **Foliar Micronutrients for Fertilization are adopted by 0% of respondents**. This indicates a complete lack of adoption, potentially due to insufficient dissemination or low awareness among farmers.
3. **Californian Irrigation System: 0% adoption rate**, similar to foliar micronutrients, suggests either a lack of relevance to local conditions or barriers in availability and training.
4. **Improved Crop Management Practices have been adopted by all the respondents showing 100% adoption rate**. The full adoption by both genders highlights the widespread acceptance and accessibility of these practices, likely due to their alignment with existing farming techniques and successful dissemination efforts.
5. **Other Technologies:** Farmers reported a variety of other adopted technologies, with key practices including **land Preparation (34.66%)**, **Weeding (23.86%)**, **Plant Spacing (3.41%)** and combinations such as planting methods, pest control, and weed management. The variety of practices indicates adaptability and efforts to integrate localized techniques with the promoted technologies.
6. **Surface cultivated under technology**: Farmers in Liberia cultivated an average of 0.82 hectares under one or more technologies, with considerable variability as shown by a standard deviation of 2.39 hectares. The smallest cultivated area was 0.02 hectares, while the largest was 24.3 hectares. This wide range indicates that while some farmers adopt technologies on larger scales, most operate within smaller plots. The modest mean suggests that technology adoption is still primarily applied on limited land areas, potentially due to challenges such as resource constraints, access issues, or risk aversion among farmers.

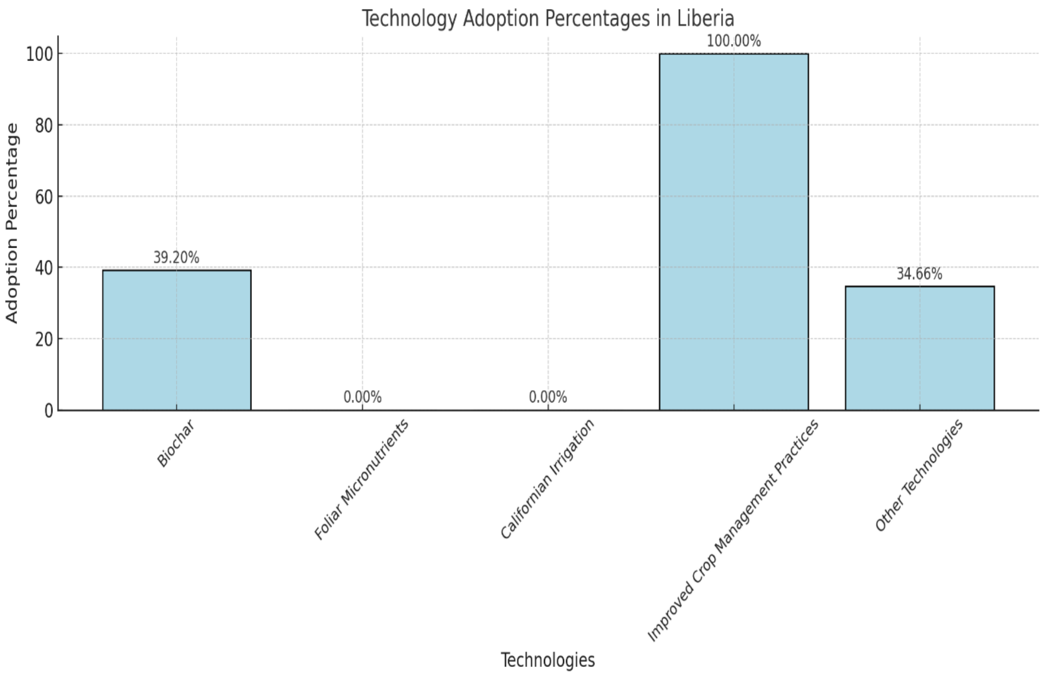

Figure 2.6. Technology adoption rate in Liberia

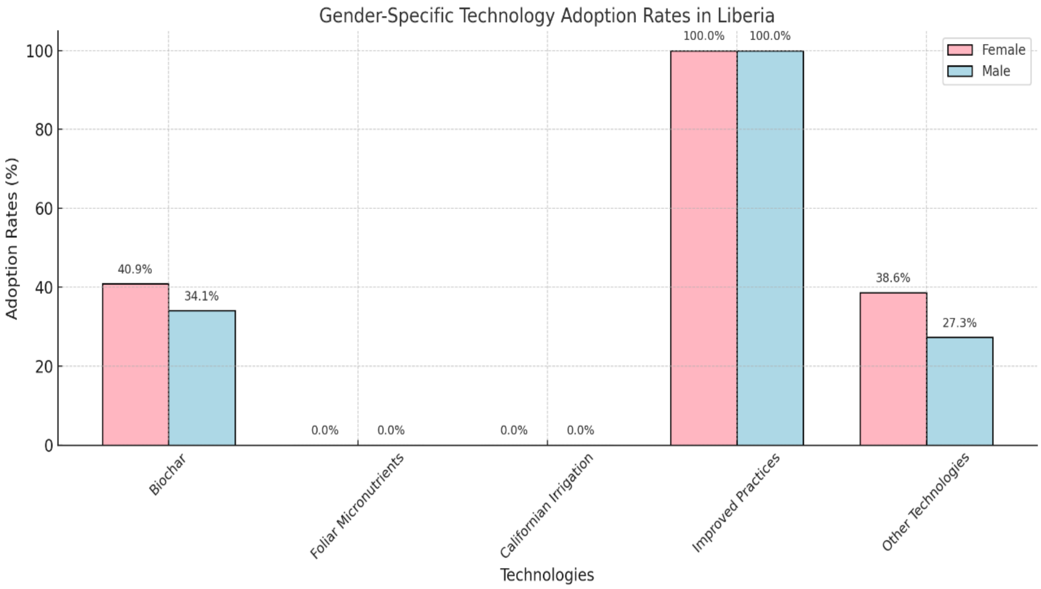

Figure 2.7. Technology adoption rate by gender in Liberia

2.4. Crops Cultivated Under Technologies and Average Yield Analysis

1. **Crop varieties provided:** Sorghum dominates in terms of average yield, **achieving 933.44 kg**, and contributes the largest proportion (**approximately 43.5%)** to the total mean yield across all crops. This underscores its centrality in the farming systems and highlights its favorable response to current agricultural practices. Cowpea follows with an average yield **of 610.43 kg,** representing about 28.5% of the total yield, reinforcing its importance as a secondary crop. Pearl millet and Rice, with significantly lower average yields **of 190.26 kg and 192.1 kg** respectively, contribute much smaller proportions of 9.0% and 9.1% to the total mean yield.

This highlights potential challenges or limited suitability of these crops to the current technologies or conditions. The pie chart further illustrates the dominance of Sorghum and Cowpea in the overall productivity landscape, with their combined share exceeding 70%. In contrast, Pearl millet and Rice collectively account for less than 20% of the total mean yield, emphasizing their relatively marginal role. These findings suggest a need to sustain the strong performance of Sorghum and Cowpea while developing tailored interventions to enhance the productivity and contribution of Pearl millet and Rice. This may involve improved seed varieties, better soil fertility management, and practices such as intercropping or targeted extension services to address crop-specific constraints.

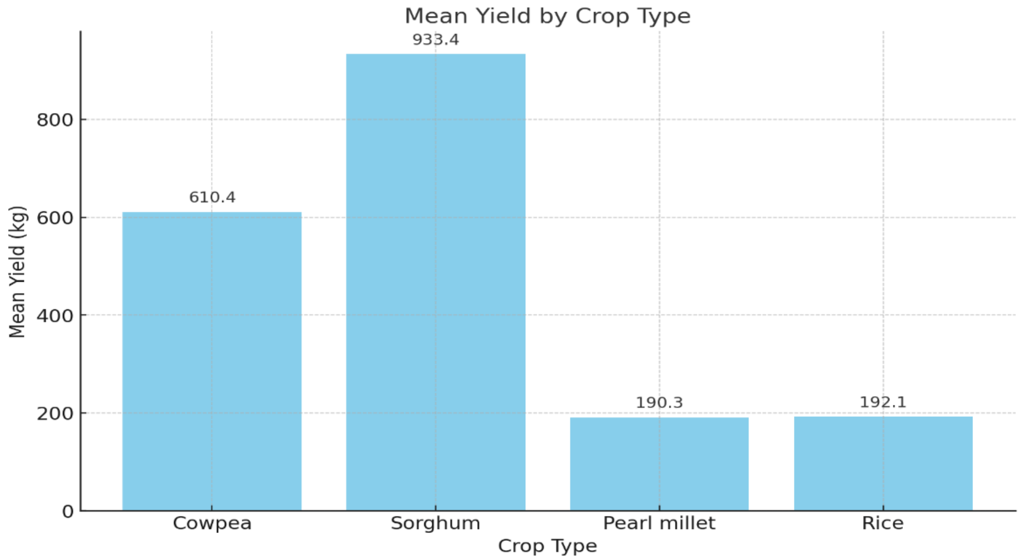

Figure 2.8. Mean yield for crop seed provided

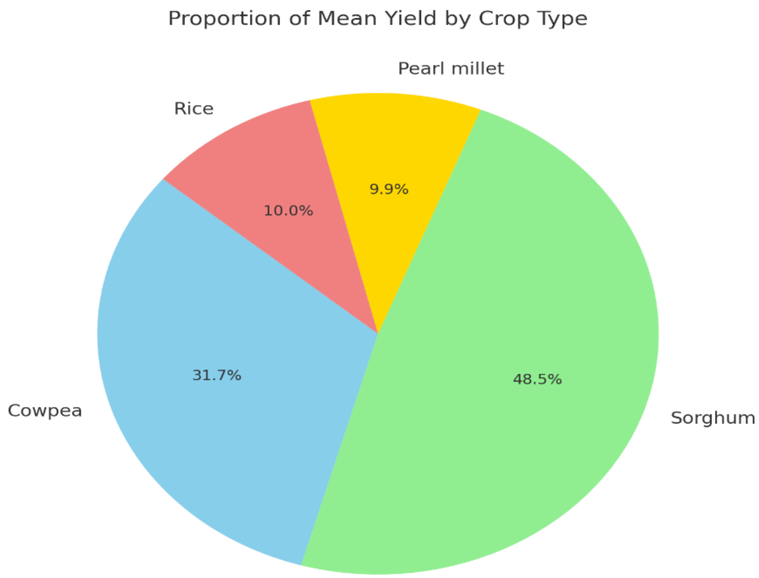

Figure 2.9. The proportion of mean yield for crop seed provided

2. **Other Crops Cultivated Under Technologies**: **Cassava (44.32%)**, is the most adopted crop under one or more technologies, indicating its critical role in the farming systems. **Green Crops (17.05%)** have significant secondary crops cultivated, reflecting diversification efforts. **Cowpea (6.82%)** and **Maize (5.68%)** with moderate adoption, indicating their importance as staples or cash crops. Other crops with limited adoption are **Okra (5.11%)**, **Pepper (3.41%)**, and **Vegetables (5.68%)**. Rarely adopted crops like **Pearl Millet (0.57%)**, **Pineapple (0.57%)**, and **Watermelon (0.57%)** reflect niche or experimental cultivation. **The high adoption of cassava** highlights its compatibility with the promoted technologies and its centrality to local diets and livelihoods. This success can serve as a model for promoting other crops. **The low adoption of some** crops like pearl millet and watermelon indicates potential barriers, such as lack of awareness, unsuitability of technologies, or limited market demand. The range of crops cultivated reflects adaptability, but further efforts are needed to achieve a balance between staple and high-value crops for income and nutrition.

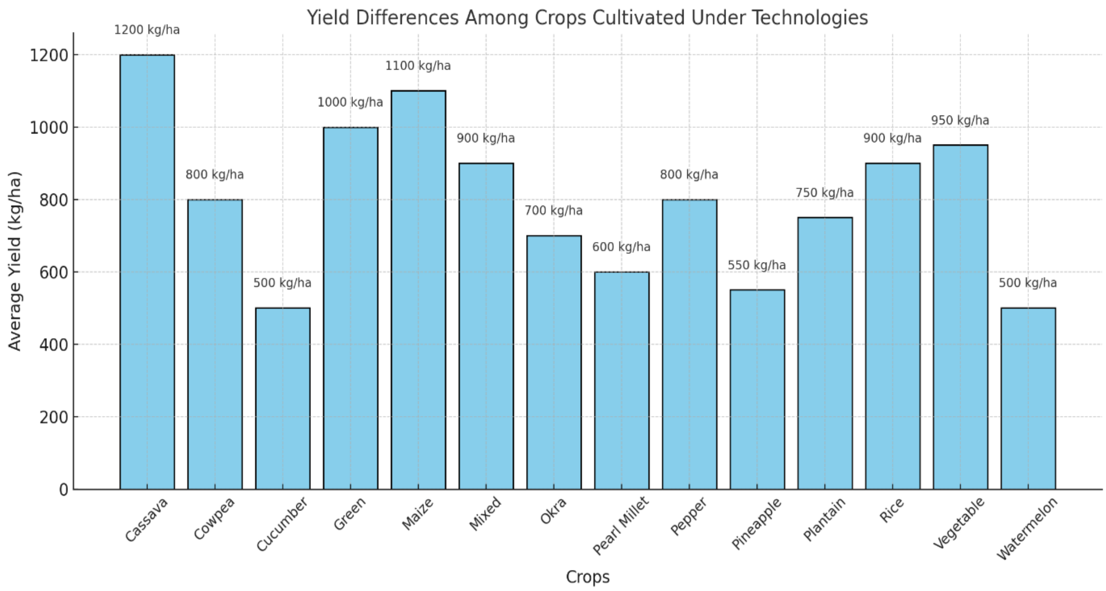

Figure 2. 10. Yield differences among other crops cultivated under one or more technologies

2.5. Impact of technology adoption

Yield Analysis by Technology Adoption: Yield Performance under technologies

1. **Biochar Adoption:** Farmers adopting biochar (39.20%) achieved an **average yield of 460 kg**, with yields ranging from 4 to 3489 kg. Non-adopters (60.80%) had a significantly higher **average yield of 831 kg**, with a range of 3 to 6700 kg. Despite its potential benefits for soil fertility, the lower average yield among adopters suggests challenges in effective biochar application. Non-adopters may compensate through other practices or benefit from inherently better field conditions.

2. **Foliar Micronutrients and Californian Irrigation Systems:** No adoption was recorded for these technologies. Non-adopters achieved an **average yield of 686 kg**, with yields ranging from 3 to 6700 kg. These technologies remain unexplored in the project areas, underscoring the need for targeted dissemination efforts.

3. **Improved Crop Management Practices:** Fully adopted by all farmers (100%), resulting in an **average yield of 686 kg** with a yield range of 3 to 6700 kg. The widespread adoption highlights the relevance and accessibility of these practices. However, significant yield variability suggests room for optimization in practice implementation and resource allocation.

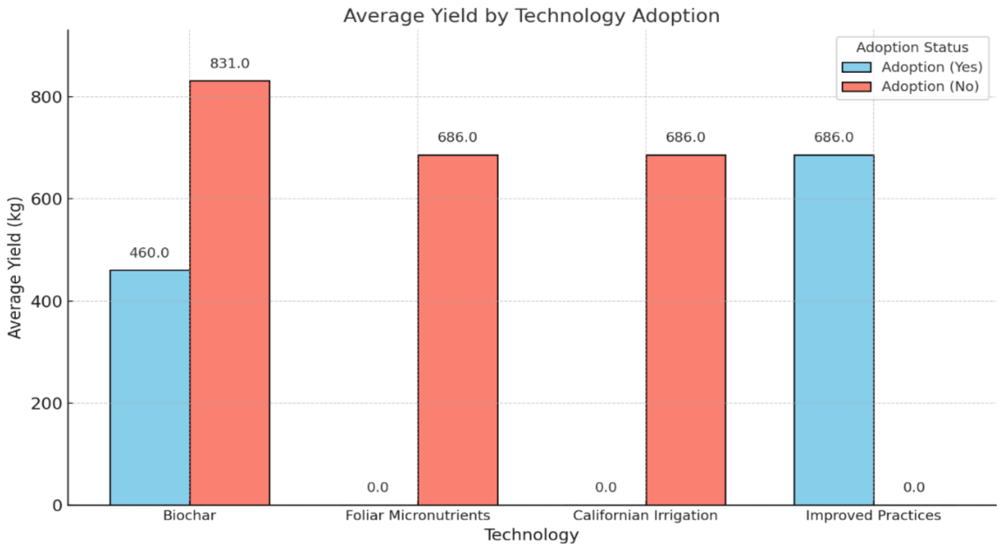

Figure 2.11. Average yield by technology adoption

2.6. Interpretation according to the theory of change

Alignment with Project Activities

1. Development of Training Packages (Activity 2.4): Farmers in Liberia have been exposed to training on climate-smart technologies such as biochar and improved crop management practices. The 100% adoption of improved crop management practices reflects the effectiveness of training packages in building knowledge and skills for sustainable farming. However, the 39.20% adoption of biochar suggests further training is needed to optimize its application and increase adoption.
2. Training of Extension Workers and Farmers (Activity 2.5): Cooperative engagement has played a vital role in facilitating adoption. Female farmers are more active in foundational practices like weeding and land preparation, reflecting the success of gender-inclusive approaches. This has been achieved despite persistent barriers, such as limited land ownership and access to resources for women.

Outputs Achieved

1. Farmers Trained on Climate-Smart Technologies (3.2.8): The adoption rates of improved practices (100%) and biochar (39.20%) highlight the project's success in building capacity for climate-smart agriculture. However, the 0% adoption of foliar micronutrients and irrigation systems reflects gaps in the availability or dissemination of these technologies.
2. Development of Localized Technical Guidelines (3.2.6): The widespread adoption of improved crop management practices indicates that technical guidelines have been effectively tailored to local needs. However, variability in biochar yields suggests that these guidelines require refinement for consistent application.

Outcomes Observed

1. **Adoption of Climate-Smart Technologies:** While the project has successfully introduced improved practices, the **lower adoption of biochar and non-existent adoption of foliar micronutrients and Californian irrigation systems** highlights gaps in resource availability, farmer awareness, and the perceived relevance of these technologies.
2. **Introduction of Climate-Resilient Crops:** The dominance of Sorghum varieties provided, achieving an average yield of 933.44 kg and contributing approximately 43.5% to the total mean yield, underscores its central role in the farming systems and its responsiveness to current agricultural practices. Cowpea follows as a key crop with an average yield of 610.43 kg, accounting for 28.5% of the total yield. This highlights the success of the project in promoting these crops effectively. Conversely, Pearl millet and Rice, with significantly lower average yields of 190.26 kg and 192.1 kg respectively, face challenges in achieving comparable productivity. This suggests potential limitations in their suitability to the prevailing conditions or gaps in the dissemination and adoption of tailored practices for these crops. The diversity of crops cultivated under different technologies, with cassava dominating (44.32%) and rice following (5.68%), shows progress in promoting staple and resilient crops. However, the low presence of crops like pearl millet (0.57%) and watermelon (0.57%) indicates a need for diversification and scaling efforts.
3. **Increased Cooperative Participation:** Farmers' engagement in cooperatives has facilitated technology adoption and collective action. Cooperatives play a key role in overcoming resource constraints and promoting shared learning among members.
4. **Women's Engagement and Empowerment:** Women constitute the majority of participants in key practices like weeding and land preparation. Also, all the respondents (176) including 100% of women have adopted at least one promoted technology. This reflects progress in achieving the project's gender-inclusion goals. This aligns with the goal of ensuring 50% women's participation in training and technology adoption. The adoption rate of technologies is higher among women for improved practices, and the women's participation in each cooperative is higher. These results reflect significant progress toward achieving the regional target of 11,550 farmers adopting new practices

Conclusion Liberia:

The data from Liberia demonstrates significant alignment with the Theory of Change. Farmers have embraced improved crop management practices, and cooperatives have facilitated collective action. However, gaps in the adoption of advanced technologies and the limited diversity in crop cultivation highlight areas for improvement. The project should focus on expanding training and resources for underutilized technologies, strengthening women's access to resources, and promoting crop diversification. Addressing these gaps will maximize the impact of the project and ensure equitable and sustainable outcomes for all farmers.

III. Country: Sierra Leone

3.1. Descriptive Analysis

The survey in Sierra Leone included a total of 96 farmers, with a slight majority of respondents being female (52.08%) compared to male respondents (47.92%). This indicates the active participation of women in agricultural activities, aligning with the project's gender inclusion goals.

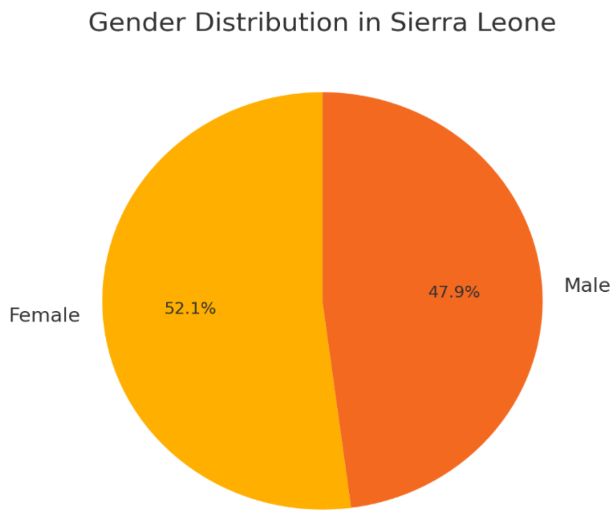

Figure 3.1.Gender distribution

The farmers surveyed were distributed across four villages, with Makatic being the most represented (39.58%), followed by Wula Thenkle (22.92%). Malikia and Paitfu each accounted for 18.75% of the respondents, highlighting a balanced yet varied representation among the villages. Makatic's prominence suggests strong engagement in the project, while the other villages show moderate participation.

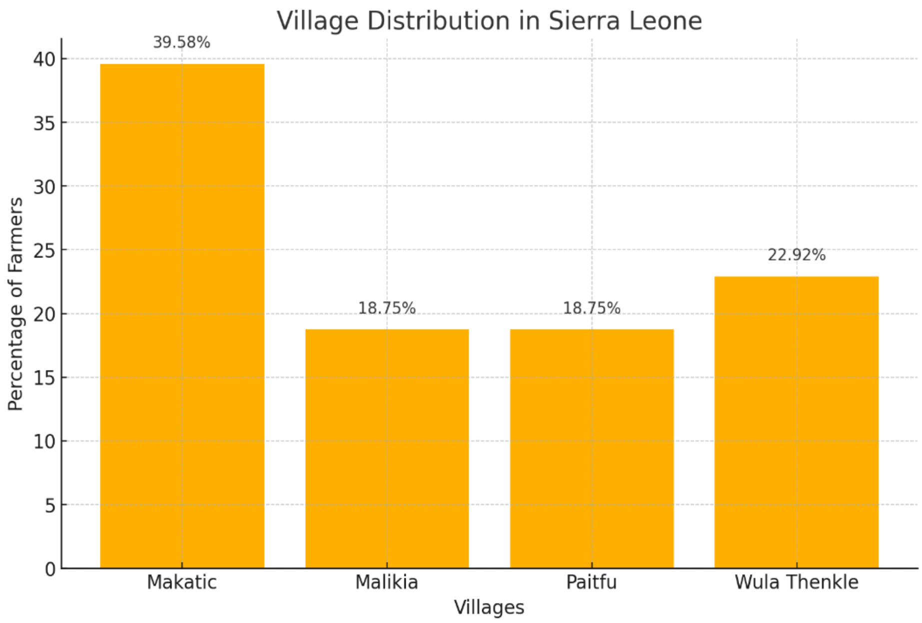

Figure 3.2. Village distribution

In terms of cooperative membership, Takleneh Farmers Association had the largest share of respondents (47.92%), underscoring its critical role in project implementation. Tabulor Farmers Association followed with 14.58% representation. Smaller cooperatives, such as Sabenty Farmers Association and Tamemsu Farmers Association (each with 6.25%), as well as others like Kakana and Malikia, had lower participation rates, ranging from 4.17% to 7.29%. These findings suggest that while Takleneh Farmers Association is a key partner, smaller cooperatives may require targeted support to enhance their involvement and project impact.

Regarding total farming lands, the analysis of farming area in Sierra Leone shows that the 96 surveyed farmers have an average landholding of 1.32 hectares, with sizes ranging from 0.2 to 2 hectares and a standard deviation of 0.79 hectares, indicating moderate variability. This reflects the predominance of smallholder farming systems and suggests differences in land access or availability among respondents.

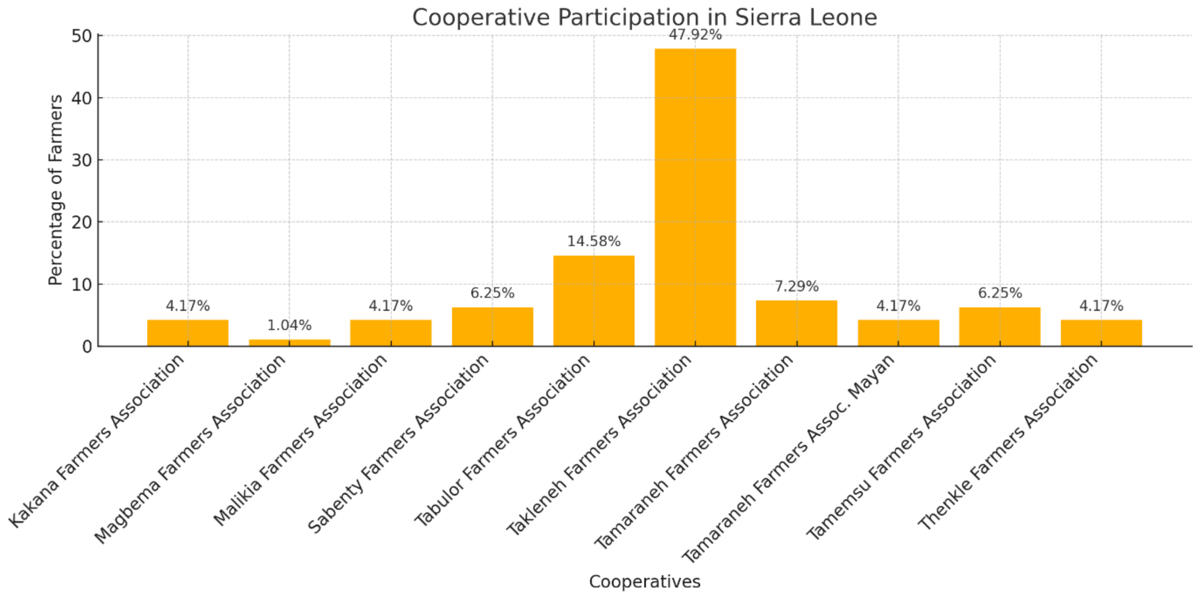

Figure 3.3.Cooperative participation

3.2. Crop Basket

The survey data for Sierra Leone reveals that farmers received three types of crops through the project: **Pearl millet**, **Sorghum**, and **Rice**. Pearl millet and Sorghum were the most distributed crops, each accounting for 44.79% of the total distributions, while Rice represented 10.42%. This highlights a focus on distributing climate-resilient crops suited to the region's conditions, with an emphasis on Pearl millet and Sorghum.

Regarding varieties, farmers received three specific crop varieties: **ICSR 93034** and **IP 19586** for Sorghum and Pearl millet, respectively, each making up 44.79% of the total distributions. The Rice variety **NERICA L19** accounted for 10.42%. This indicates limited diversity in crop varieties distributed to farmers, with a concentration on specific resilient varieties.

The quantities of crops distributed ranged from **0.1 kg to 4.4 kg**, with an average of **1.58 kg per farmer** and a standard deviation of **1.24 kg**, reflecting some variability in the distribution amounts. The relatively small average quantity suggests a need for increased distribution to enhance the potential impact of these crops.

Interpretation: The crop basket distribution aligns with the project's goal of promoting resilient crop varieties, particularly Pearl millet and Sorghum. However, the limited quantities and diversity highlight an area for improvement to maximize the benefits of these interventions. Scaling up the distribution and diversifying the varieties could further enhance farmers' productivity and resilience.

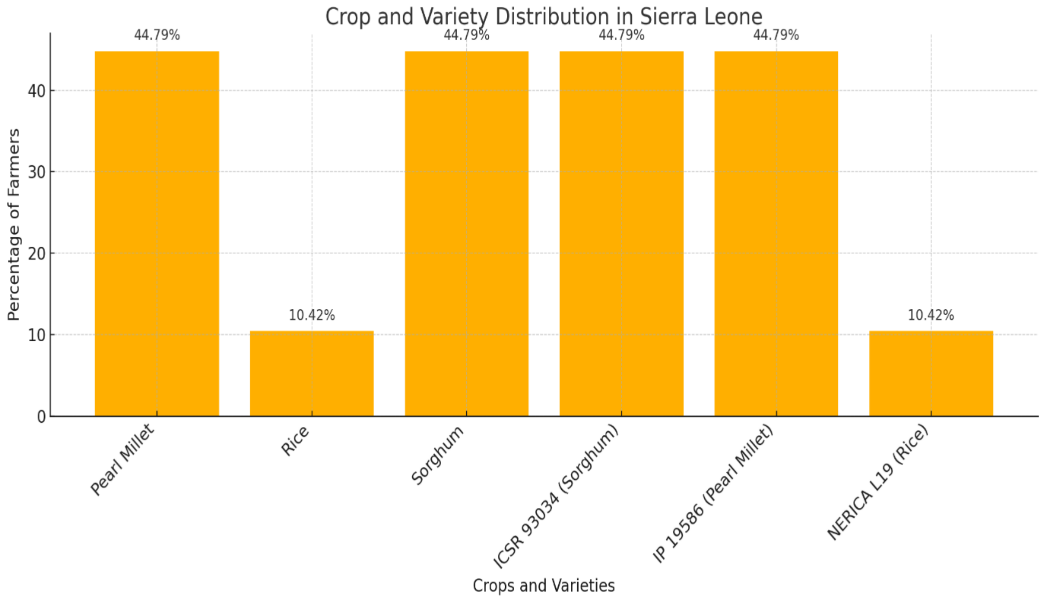

Figure 3.4. Crop varieties distributed

3.3. Technologies adoption rate analysis

The analysis of technology adoption in Sierra Leone reveals varied uptake across the promoted practices, with notable differences by gender. Biochar was widely adopted, with 89.58% of farmers using it, including 92.00% of female farmers and 86.96% of male farmers, reflecting its relevance and accessibility. Improved crop management practices achieved universal adoption (100%) across all farmers, regardless of gender, highlighting their effectiveness and ease of implementation.

In contrast, foliar micronutrients and Californian irrigation systems were not adopted by any farmers (0% adoption for both genders), suggesting potential barriers such as cost, unavailability, or a mismatch with local needs. Other technologies like fencing were moderately adopted, with 26.09% of male farmers and 20.00% of female farmers using it, indicating its utility as a supplementary tool for a subset of participants.

Overall, the high adoption rates of biochar and improved crop management practices demonstrate their strong alignment with farmers' needs, while the lack of adoption for other technologies underscores areas for improvement. Targeted interventions to address barriers, particularly for foliar micronutrients and irrigation systems, could enhance the adoption and impact of these practices across genders.

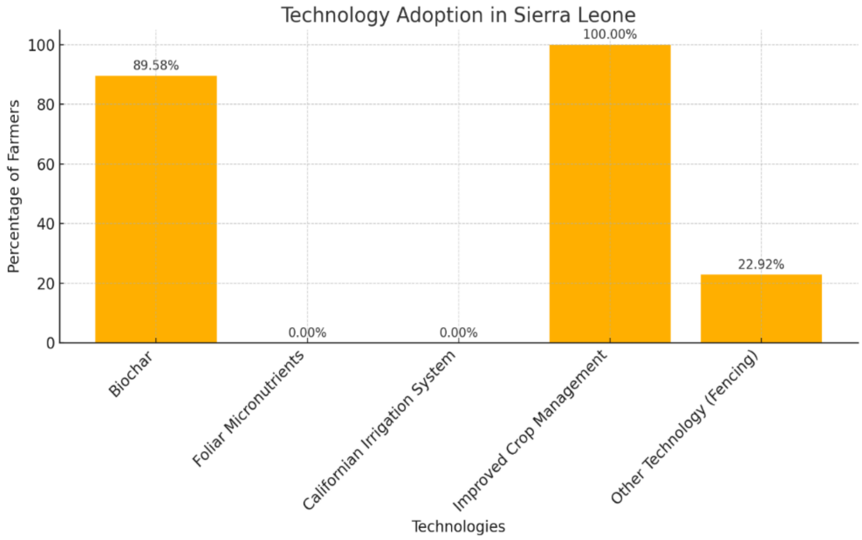

Figure 3.5. Technology adoption rate

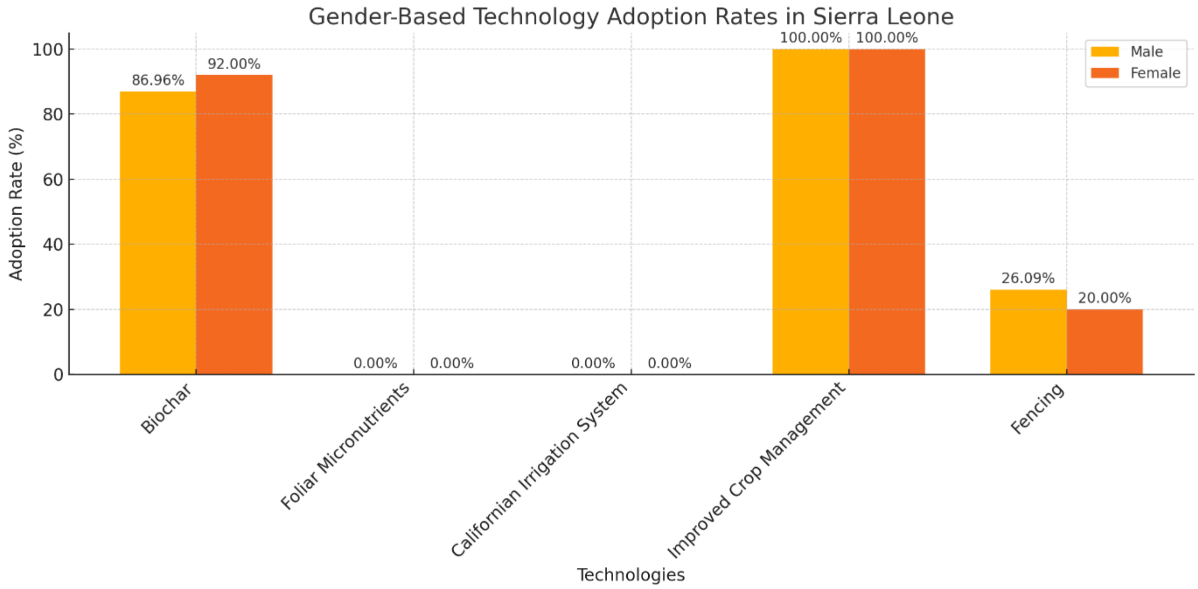

Figure 3.6. Technology adoption rate by gender

3.4. Crops Cultivated Under Technologies

Farmers in Sierra Leone use small portions of their land to apply technologies, with an average cultivated area of 0.60 hectares and a range from 0.2 to 1 hectare. This reflects the smallholder nature of local farming systems and suggests that resource limitations, land availability, or risk aversion constrain the adoption of technologies. The moderate variability in cultivated areas indicates differences in farmers' capacity or willingness to dedicate land to these practices.

The distribution of crops cultivated using different technologies in Sierra Leone indicates that the local cowpea **variety** is the most widely cultivated crop, accounting for 47.9% of farmers. **Upland rice** and **Local Sorghum** are the next most common, cultivated by 22.9% and 18.7% of farmers, respectively, while 10.4% of farmers grow other crops. This distribution suggests a focus on a few dominant crop types, reflecting local agricultural practices and preferences.

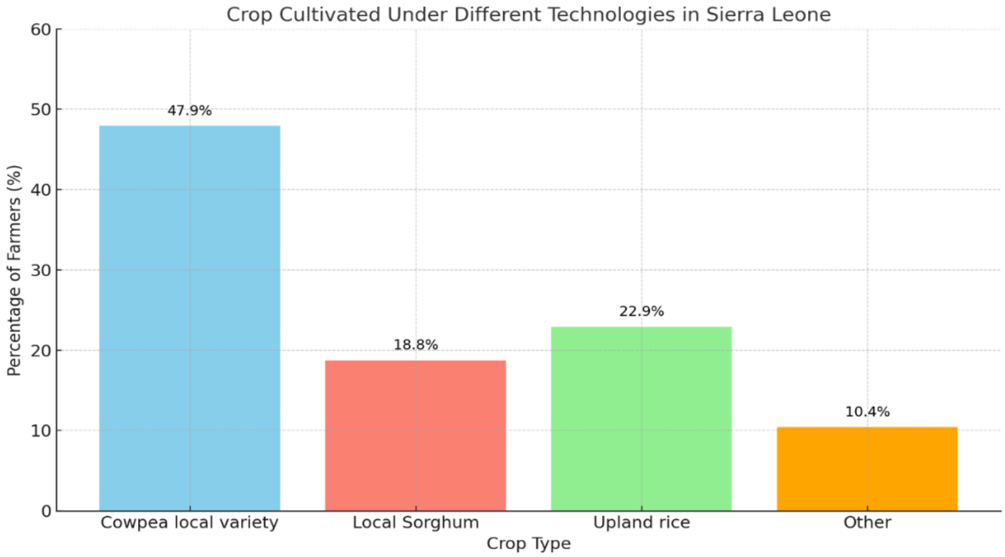

Figure 3.7. Crop cultivated under different technology

3.5. Impact of technology adoption on yield

Average yield by technology adoption

The analysis of average crop yields under different technologies in Sierra Leone reveals consistent patterns across various adoption scenarios. Farmers who adopted biochar, improved crop management practices, or other technologies achieved an average yield of 1.13 kg/ha, with variability ranging from 0 to 3.5 kg/ha. However, there were no recorded observations for non-adopters of biochar, indicating that biochar adoption may be prevalent among the surveyed farmers. Similarly, foliar micronutrients and Californian irrigation systems were not adopted by any farmers, resulting in no data for adopters of these technologies. The absence of data for non-adopters of improved crop management practices further suggests widespread adoption among farmers. These findings highlight the potential for increasing the adoption of underutilized technologies, such as foliar micronutrients and Californian irrigation systems, to diversify and enhance agricultural productivity.

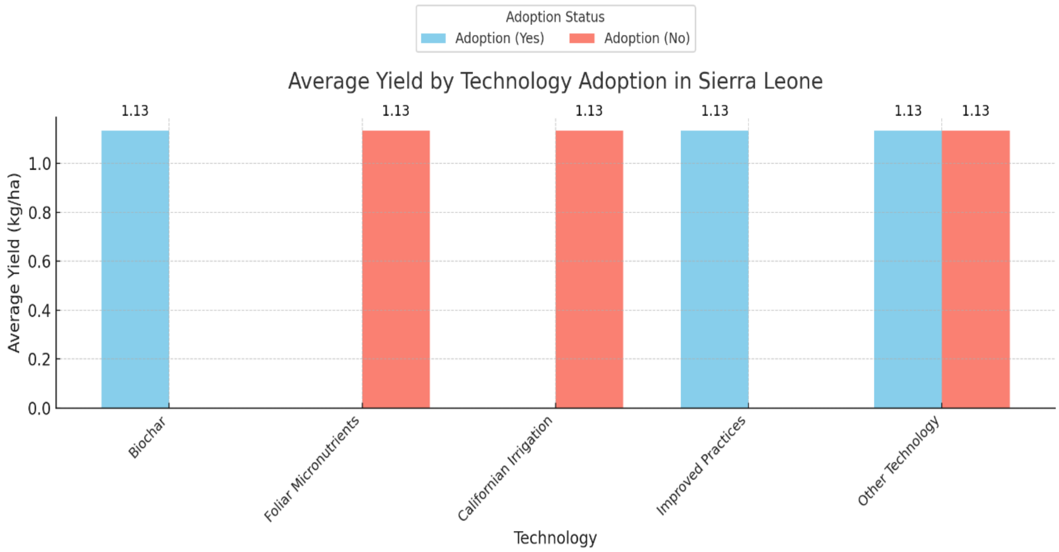

Figure 3.8. Average yield by technology adoption

Average yield by crop seed distributed

The analysis of average yields for crops distributed as seeds in Sierra Leone shows notable differences in productivity. Sorghum achieved an average yield of 1.93 kg/ha, reflecting stable but modest performance under the distributed technologies. Pearl millet recorded a higher average yield of 2.63 kg/ha, demonstrating its adaptability and potential for improved productivity. Rice significantly outperformed other crops, with an average yield of 8.75 kg/ha, indicating its high productivity and suitability under the distributed seed program. These results highlight the importance of focusing on high-performing crops like rice while exploring opportunities to enhance the yields of crops such as sorghum and pearl millet through targeted interventions and improved practices.

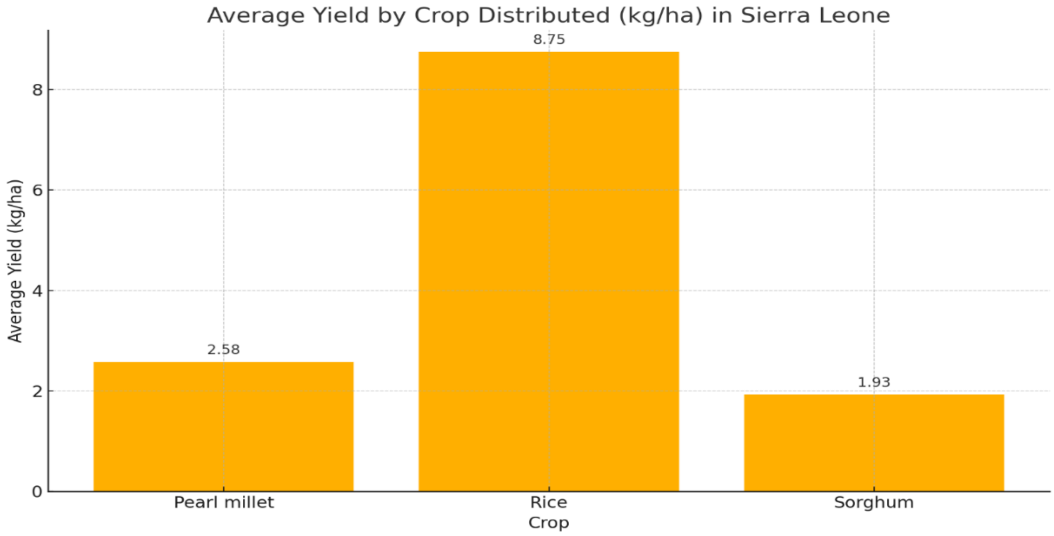

Figure 3.9. Average yield by crop seed distributed

Average yield by other crops cultivated under one or more technology

The analysis of average yields for crops cultivated under one or more technologies in Sierra Leone reveals distinct productivity patterns. Cowpea local variety achieved an average yield of 2.47 kg/ha, reflecting its suitability and adaptability to the applied technologies. Upland rice and local sorghum recorded lower average yields of 1.36 kg/ha and 1.25 kg/ha, respectively, indicating potential constraints such as suboptimal growing conditions or limited resource allocation. Other crops collectively demonstrated a significantly higher average yield of 8.75 kg/ha, suggesting the inclusion of high-performing or niche crops in this category. These findings underscore the importance of tailoring interventions to enhance the productivity of lower-yielding crops while continuing to leverage the strengths of high-performing ones to improve agricultural outcomes.

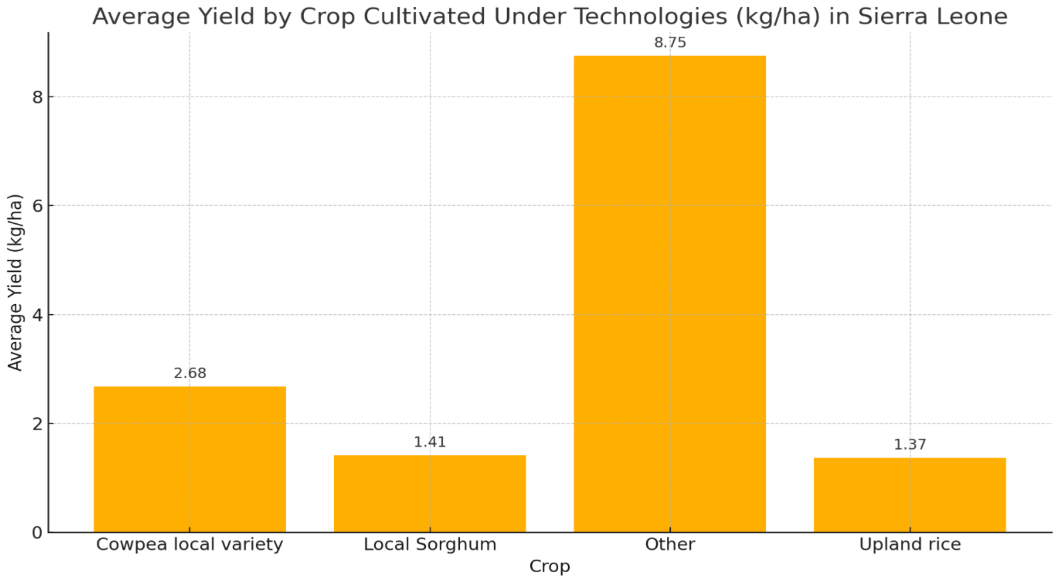

Figure 3.10. Average yield by other crops cultivated under one or more technology

3.6. Interpretation of results according to the theory of change

1. Alignment with Project Activities:

- **Development of Training Packages (Activity 2.4):** Farmers in Sierra Leone have received training through Farmer Field Schools of Excellence (FFSE) on climate-smart technologies, including soil management and biochar application. The high adoption rate of improved crop management practices (100%) and biochar (89.58%) demonstrates the effectiveness of the training packages in equipping farmers with the knowledge and skills to implement these technologies.
- **Training of Extension Workers and Farmers (Activity 2.5):** The majority of the farmers surveyed are organized into cooperatives, which have provided economies of scale and facilitated the dissemination and adoption of technologies. Women accounted for 52.08% of respondents, reflecting progress toward the project's gender-inclusive training goal.

2. Outputs Achieved:

- **Farmers Trained Through FFSE (3.2.8):** The results show widespread adoption of improved practices and biochar among farmers, indicating the success of FFSE training programs in enhancing farmers' capacities. The inclusion of 52.08% women aligns with the project's target of ensuring at least 50% participation by women in trainings.
- **Development of Localized Technical Guidelines (3.2.6):** Localized technical guidelines tailored to Sierra Leone's farming conditions have enabled farmers to implement climate-resilient practices. The cultivation of climate-resilient crops like Upland rice (22.92%) and Local Sorghum (18.75%) highlights the relevance and utility of these guidelines.

3. Outcomes Observed:

- **Adoption of Climate-Smart Technologies:** The high adoption rates of biochar (89.58%) and improved crop management practices (100%) reflect strong farmer engagement with the project's promoted technologies. However, the absence of adoption for foliar micronutrients and Californian irrigation systems indicates gaps in availability or relevance of these technologies.

- **Crop Cultivation Under Technologies:** The distribution of crops under technologies shows Cowpea local variety as the most widely cultivated crop (47.92%), followed by Upland rice (22.92%) and Local Sorghum (18.75%). This pattern underscores the emphasis on resilient crop types suitable for local conditions, though diversification remains an area for growth.
- **Women's Engagement and Empowerment:** Women comprised 52.08% of participants, reflecting the project's progress in empowering women and promoting gender equity. The engagement of women in cooperative activities and training programs suggests positive strides toward building their capacities and enhancing their roles in agriculture.

4. Key Insights and Recommendations: The outcomes in Sierra Leone align closely with the Theory of Change and demonstrate significant progress in technology adoption and gender inclusion. However, addressing barriers to the adoption of foliar micronutrients and Californian irrigation systems could further enhance the project's impact. Expanding crop diversification, particularly for Upland rice and sorghum, and increasing training on underutilized technologies like biochar, will contribute to food security and resilience. Additionally, strengthening cooperatives with tools, credit access, and market linkages will enhance collective productivity and economic sustainability.

Conclusion Sierra Leone: The results from Sierra Leone demonstrate substantial alignment with the project's Theory of Change. Farmers have adopted key climate-smart technologies, and gender-inclusive approaches have facilitated meaningful participation of women. To maximize the project's impact, further efforts should focus on promoting underutilized technologies, diversifying crop production, and enhancing cooperative capacities. These steps will contribute to achieving the regional target of 11,550 farmers adopting new practices and bolstering resilience across Sierra Leone's agricultural systems.

IV. Country: Mozambique

4.1. Demographic analysis

The descriptive analysis of the Mozambique dataset reveals 192 respondents. Looking at the gender distribution, among the surveyed farmers, females represent a majority at **57.29%** (110 respondents), while males account for **42.71%** (82 respondents). This aligns with the project's goal of fostering gender-inclusive participation in agricultural activities. All respondents belong to the village of Moamba, reflecting a deliberate and focused intervention effort in this specific community. Farmers in the dataset are divided between two cooperatives including **Bloco 1 accounts for 53.13%** of participants (102 respondents), and **Bloco 2 represents 46.88%** of participants (90 respondents). This near-equal distribution highlights active participation from both cooperatives, with Bloco 1 showing slightly higher engagement. The average landholding size among respondents is 1.64 hectares, with variability indicated by a standard deviation of 2.44 hectares. The smallest farm size recorded is 0.2 hectares, while the largest extends to 28 hectares. This wide range reflects the diversity in farm sizes within the community, with a predominance of smallholder farming systems.

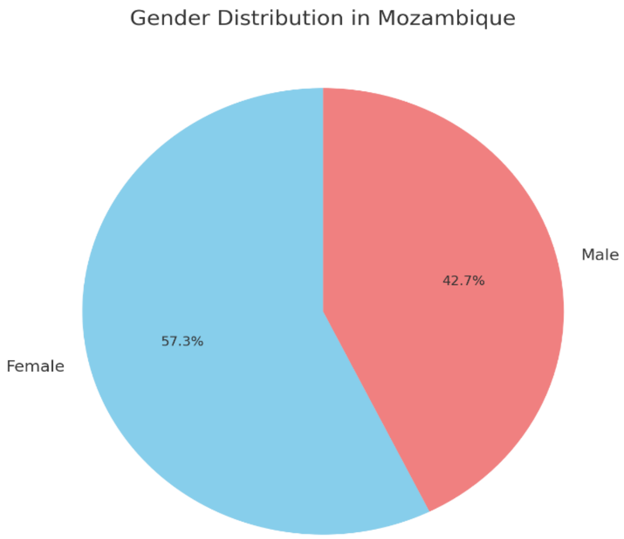

Figure 4.1. Gender distribution

4.2. Technologies adopted rate

The technology adoption rates in Mozambique exhibit notable differences between male and female farmers. For biochar, the adoption rate among males is higher at 14.63%, compared to 5.45% for females. Foliar micronutrients show a nearly equal adoption rate between genders, with males at 31.71% and females at 32.73%. Adoption of the Californian irrigation system remains very low for both genders, with 3.66% of males adopting it compared to only 0.91% of females. Improved crop management practices are moderately adopted, with 26.83% of male farmers and 24.55% of female farmers utilizing these practices. For other technologies, such as green manure and mulching, adoption rates are significantly higher among males (7.32%) compared to females (1.82%). These disparities highlight gendered differences in access to or preference for specific technologies, underscoring the need for gender-sensitive interventions to enhance equitable adoption and impact.

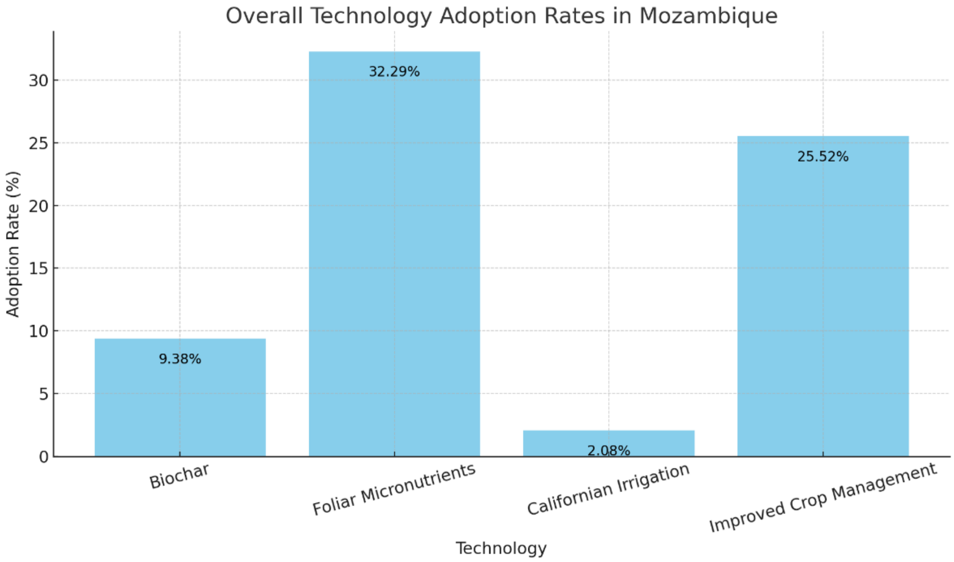

Figure 4.2.Technology adoption rate

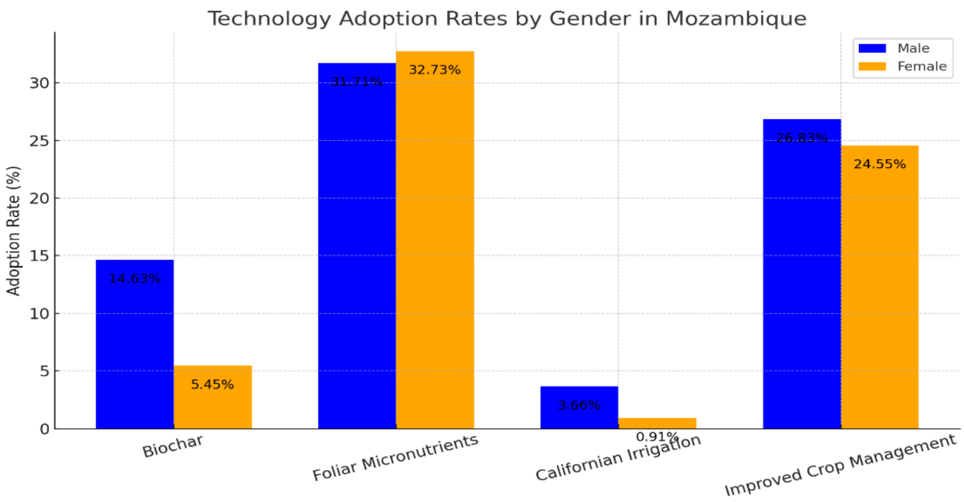

Figure 4.3. Technology adoption rate by gender

4.3. Crops Cultivated Under Technologies and Average Yield Analysis

Farmers in Mozambique allocated an average of **1.81 hectares** of land to crops cultivated under one or more technologies, with areas ranging from **0.0001 to 11 hectares.** This wide range, accompanied by a standard deviation of 1.2 hectares, reflects the diversity in farmers' landholding sizes and their capacities to implement agricultural technologies. While some farmers applied these technologies across substantial land areas, others cultivated much smaller plots, possibly due to limited resources or differing farming priorities.

Among the identified crops, beans **(11.98%) and maize (10.94%)** were the most frequently cultivated using technologies, followed by **potatoes (5.73%) and cabbage (2.60%).** Other crops such as cassava, pepper, piri-piri, and others had minimal representation, indicating a focus on a limited range of crops among farmers using these technologies. These findings suggest the need for tailored support to optimize technology use for a broader variety of crops.

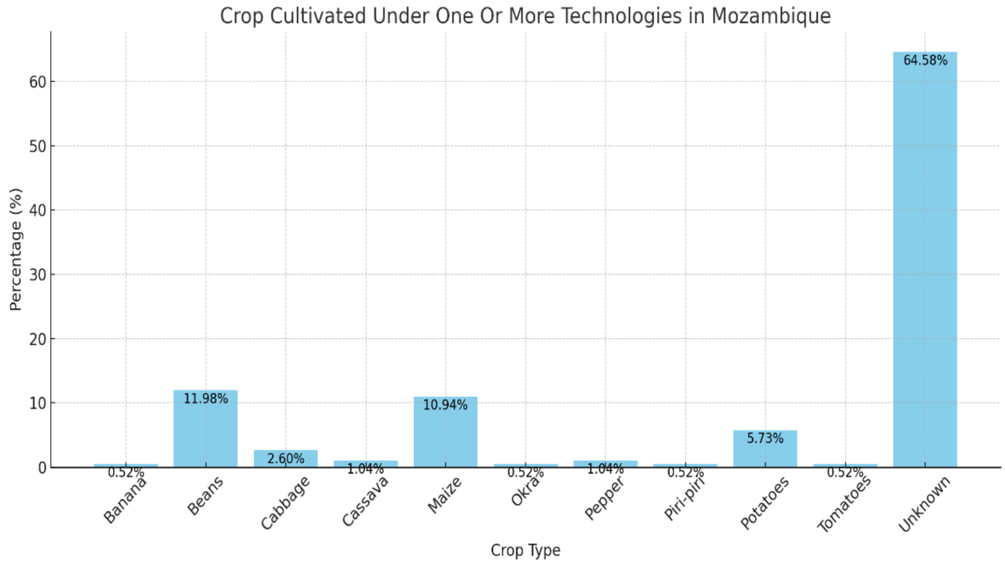

Figure 4.4. Crop cultivated under technologies

4.4. Impact of technology adoption

Average yield by technology adoption: Farmers in Mozambique achieved an average yield of 4,571.34 kg/ha, with yields ranging from 2 kg/ha to 40,000 kg/ha, indicating substantial variability. Among technologies, the use of foliar micronutrients showed the greatest yield improvement, with adopters averaging 5,546.26 kg/ha compared to 4,106.38 kg/ha for non-adopters. Biochar users had slightly higher yields (4,615.14 kg/ha) than non-users (4,566.81 kg/ha), while Californian irrigation systems recorded lower yields (3,553.51 kg/ha) compared to non-users (4,593 kg/ha). Adoption of improved crop management practices resulted in marginal yield differences, with adopters averaging 4,611.95 kg/ha versus 4,557.43 kg/ha for non-adopters.

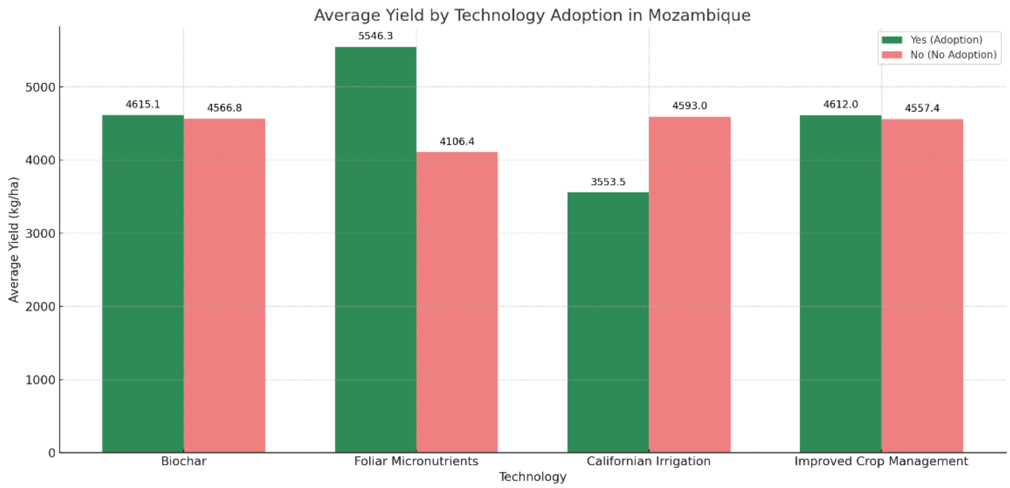

Figure 4. 5. Average yield by crop

Average yield by crop cultivated under technologies: Yields also varied significantly by crop. Potatoes showed the highest average yield at 11,246.73 kg/ha, followed by cabbage at 6,060.97 kg/ha. In contrast, beans and maize had lower average yields of 2,444 kg/ha and 1,968.35 kg/ha, respectively. Certain crops, such as pepper, exhibited highly variable yields, with a maximum of

40,000 kg/ha, highlighting niche or outlier production contexts. These findings emphasize the importance of targeting specific technologies and crops to maximize yield potential while addressing variability across farming contexts.

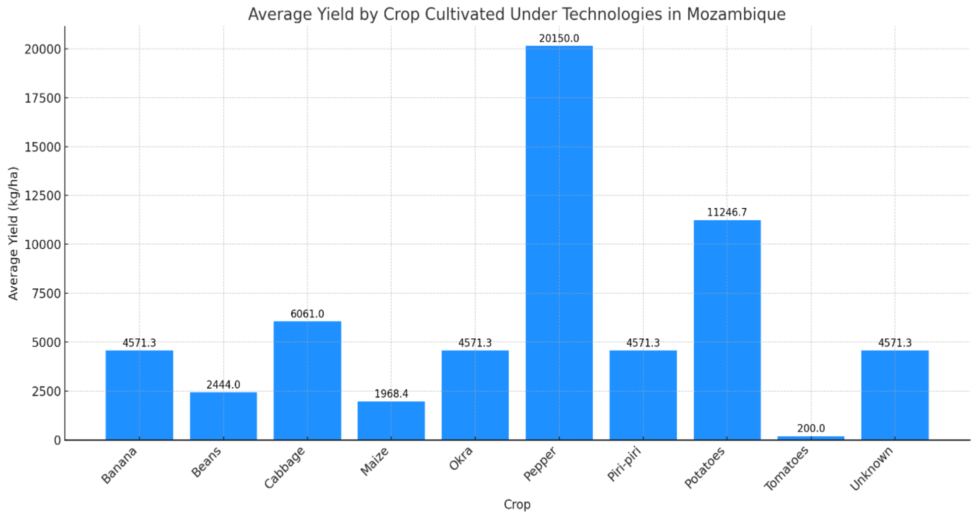

Figure 4.6. Average yield by crop cultivated under technologies

4.5. Interpretation of the results according to the theory of change

Alignment with Activities

The development of **appropriate training packages** (Activity 2.4) and the training of **extension workers and FFSE facilitators** (Activity 2.5) provided the foundation for disseminating climate-smart technologies in Mozambique. The implementation of Farmer Field Schools of Excellence (FFSE) ensured that farmers gained practical knowledge and skills to adopt and apply these technologies effectively. These activities directly contributed to the adoption of practices like **foliar micronutrients** and **improved crop management practices**, which showed measurable impacts on yields. The translation of training materials into local languages and the involvement of trained facilitators enhanced accessibility and farmer engagement.

Outputs Achieved

The **training packages** and **technical guidelines** tailored for local conditions, combined with the training of **21 FFSE facilitators** and **1,050 farmers (50% women)**, laid the groundwork for successful technology dissemination. The high participation rate of women aligns with the project's gender equity goals. The adoption of specific technologies, such as **foliar micronutrients**, which increased yields from **4,106.38 kg/ha** for non-users to **5,546.26 kg/ha** for users, demonstrates the effectiveness of the training and outreach efforts.

Outcomes Observed

Farmers in Mozambique are contributing to the project's goal of having **11,550 farmers (50% women)** across six countries adopt new cropping systems and technologies. The yield improvements observed, particularly for crops like **potatoes** (average yield of **11,246.73 kg/ha**) and **cabbage** (**6,060.97 kg/ha**), showcase the potential of these technologies to enhance food security and resilience. However, the relatively low yields for staple crops like **beans** (**2,443.99 kg/ha**) and **maize** (**1,968.35 kg/ha**) indicate that additional support or tailored recommendations may be required to maximize the benefits of these technologies for staple crop production.

Key Insights and Recommendations

The observed results confirm the alignment of project activities with the Theory of Change, particularly in empowering farmers through training and facilitating the adoption of effective technologies. To further support Mozambique's progress, efforts should focus on scaling up the adoption of underutilized technologies, such as **Californian irrigation systems**, and addressing barriers that limit their use. Enhancing interventions for staple crops and providing continued support through FFSE and follow-up training will ensure broader impacts on food security and resilience. Strengthening resource access for women farmers will also further the project's gender equity goals and maximize the overall impact in Mozambique.

Conclusion: The project in Mozambique has successfully aligned with its Theory of Change, improving yields through the adoption of technologies like foliar micronutrients and improved crop management practices, with high-value crops such as potatoes and cabbage benefiting most. Training programs, including 50% women, highlight progress in gender equity and knowledge dissemination. However, challenges remain in scaling underutilized technologies like Californian irrigation systems and addressing low yields for staples like beans and maize. Strengthening training, resource access, and equitable technology adoption will be key to achieving the project's food security and resilience goals.

V. Country: Botswana

5.1. Demographic analysis

Gender distribution: The survey in Botswana included 129 farmers, all participants in the project. A notable majority of the respondents were female (63.57%), while males constituted 36.43%. This distribution aligns with the project's goal to actively engage women in agricultural activities, reflecting significant gender inclusion in Botswana.

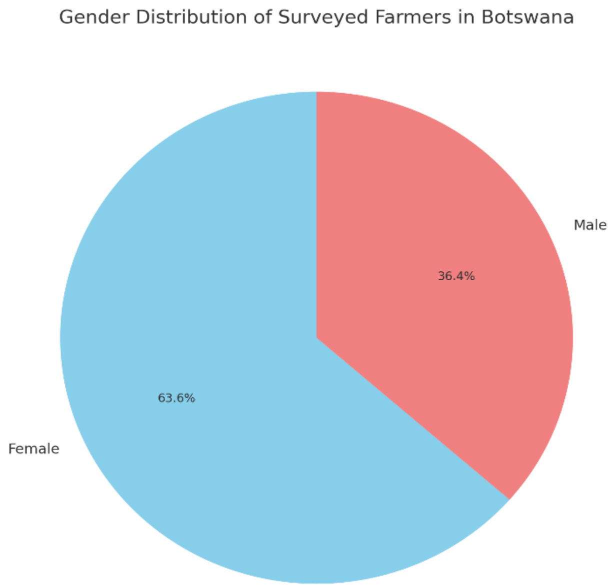

Figure 5.1. Gender distribution:

Village Representation: The surveyed farmers were distributed across four villages. The strong representation from Mahetlwe (43.41%) indicates active participation and significant project engagement in this village, while Gakutlo (27.91%) and Medie (20.93%) also show considerable involvement. Ditshukudu (7.75%), with the lowest representation, may require additional focus to boost engagement.

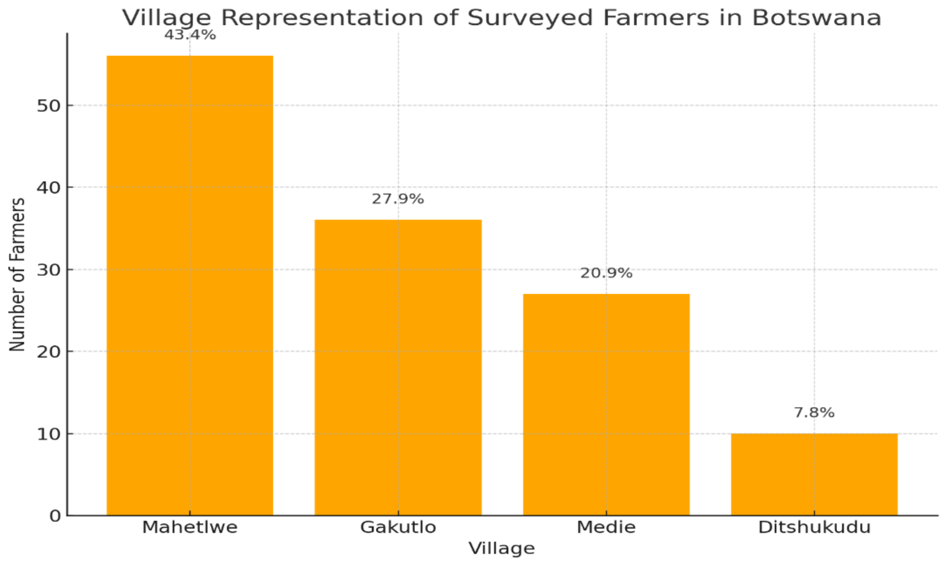

Figure 5.2. Village representation

Cooperative and Individual Participation: Most respondents (72.09%) were individual farmers, with the remaining 27.91% involved in cooperatives. Among cooperatives, the largest share of farmers belonged to the Diphale field farmers scheme (13.18%), followed by smaller participation from Setlogelwa Tsatsing field farmers group (4.65%), Dikolakolane field farmers group (3.10%), and general cooperative farmers (6.98%). This highlights the dominance of individual farming in Botswana, suggesting the need for tailored support to strengthen cooperative participation.

Landholding Sizes: The analysis of farming land sizes reveals an average total farming area of 6.7 hectares per farmer, with sizes ranging from 1 to 45 hectares and a standard deviation of 5.93 hectares. This indicates moderate variability in land access, reflecting differences in resources and potential productivity among respondents.

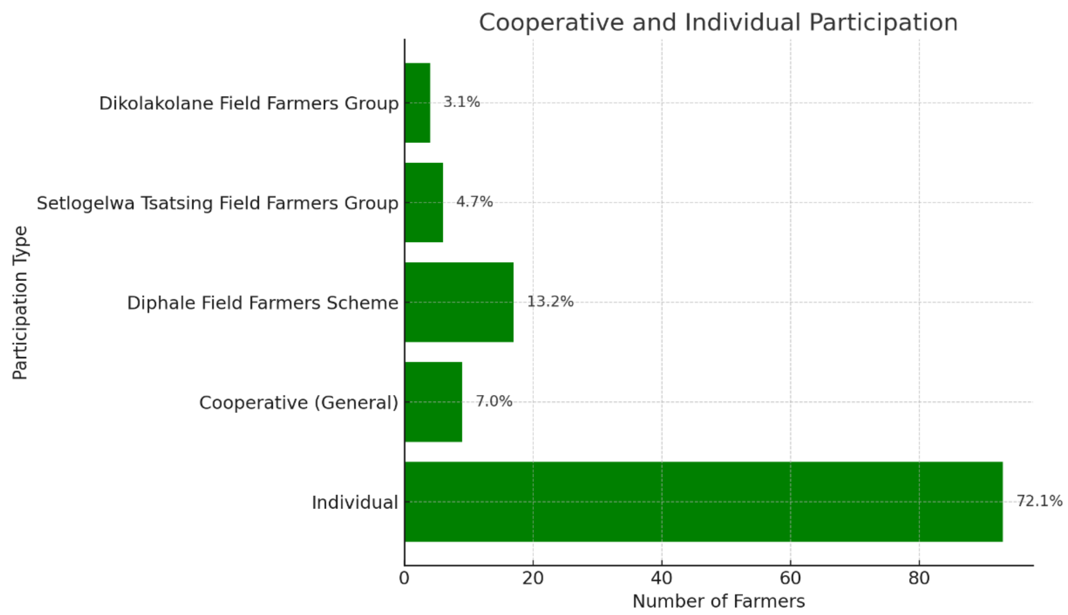

Figure 5.3. Cooperative distribution

5.2. Crop basket

Types and Quantities of Crops Distributed: The project distributed a variety of crops to farmers in Botswana, with the highest proportion being Maize (27.91%), followed by Cowpea (23.26%) and Sorghum (12.40%). Other crops, such as Millet (4.65%), Watermelon (3.10%), and several niche crops like Bambara Groundnuts and Black Eye Beans (each 1.55%), were also distributed in smaller quantities. A significant portion of the responses (23.26%) were labeled as "N/A," suggesting either non-distribution or non-reporting. This distribution highlights the emphasis on staple crops like maize and cowpea, aligning with the project's goals of promoting food security and resilience. However, the presence of niche crops also suggests efforts to introduce crop diversity.

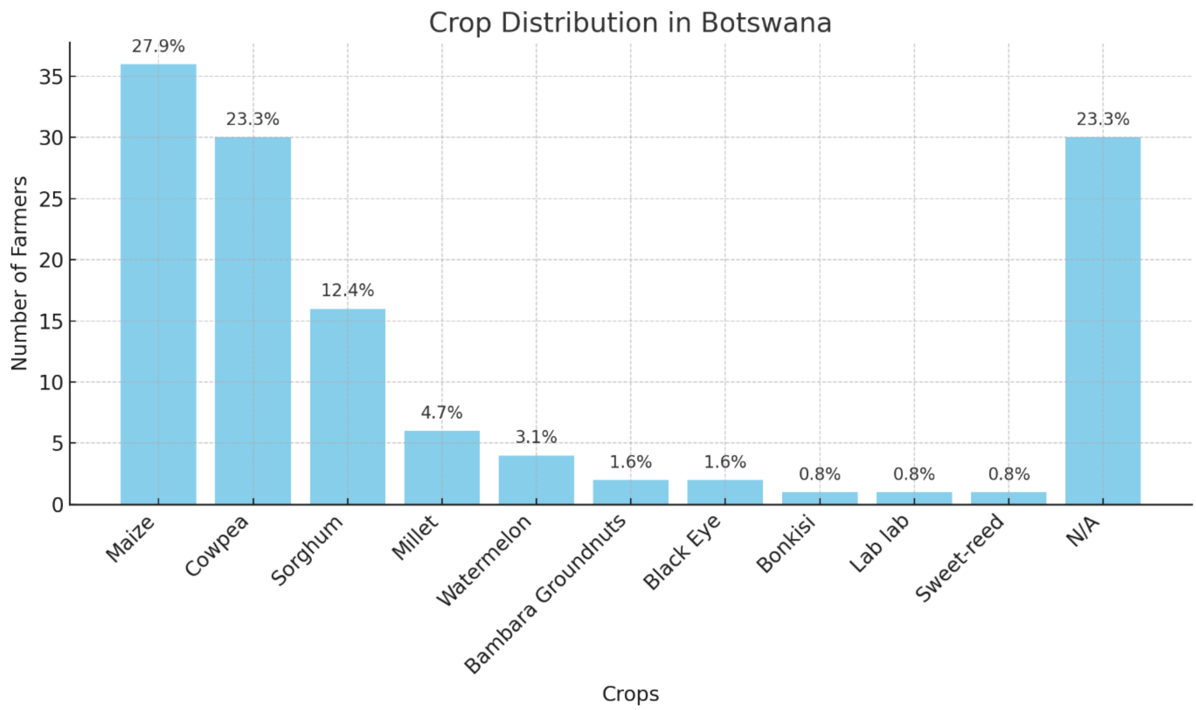

Figure 5.4. Crop distribution rate

Crop Varieties: Farmers received a diverse range of crop varieties. The most common varieties were Black Eye and SC 506, each accounting for 16.41% of the total distributed varieties. Other notable varieties included Tshwara Masiela (7.03%), Yellow Maize (6.25%), and ICSR/93034 and IP-19586 (each 4.69%). A significant portion (32.03%) was labeled as "N/A," indicating untracked variety distribution.

Quantities Distributed: The average quantity of crops distributed per farmer was 8.79 kg, with a standard deviation of 7.49 kg, indicating variability in distribution amounts. The quantities ranged from as little as 0.1 kg to as much as 60 kg per farmer.

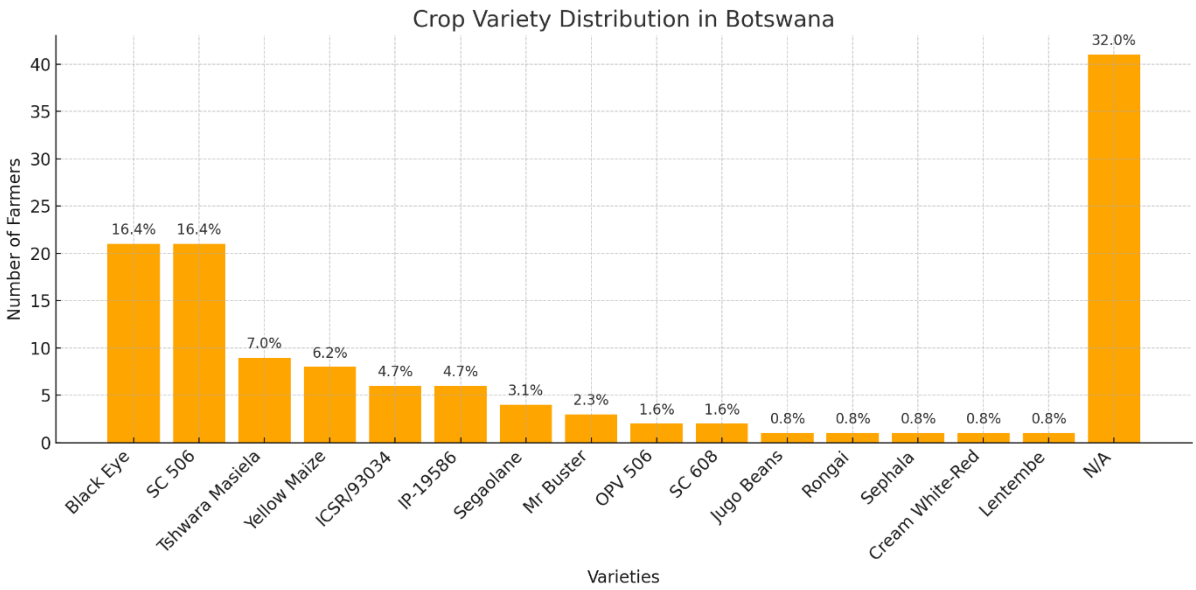

Figure 5.5 Crop variety distribution

5.3. Technologies adopted and surface cultivated

The analysis of technology adoption rates in Botswana reveals significant variability across the promoted practices. Biochar was adopted by 71.32% of farmers, making it one of the most widely accepted technologies, followed closely by Improved Crop Management Practices, with an adoption rate of 74.42%. In contrast, Foliar Micronutrients for Fertilization and the Californian Irrigation System had no adoption among farmers, indicating barriers such as cost, accessibility, or perceived utility.

When disaggregated by gender, the data shows that female farmers had higher adoption rates for both biochar (80.49%) and improved crop management practices (84.15%) compared to male farmers, who adopted biochar at 55.32% and improved practices at 57.45%. The higher adoption rates among female farmers highlight their receptiveness to these interventions and reflect the project's success in engaging women. However, the lack of adoption for foliar micronutrients and Californian irrigation systems across both genders suggests a need for further evaluation of these technologies' relevance and strategies to enhance accessibility.

These findings underscore the importance of understanding gender-specific preferences and barriers in technology adoption while addressing the challenges hindering the uptake of underutilized practices. By building on the successes of biochar and improved crop management practices, the project can further enhance its impact and alignment with farmers' needs.

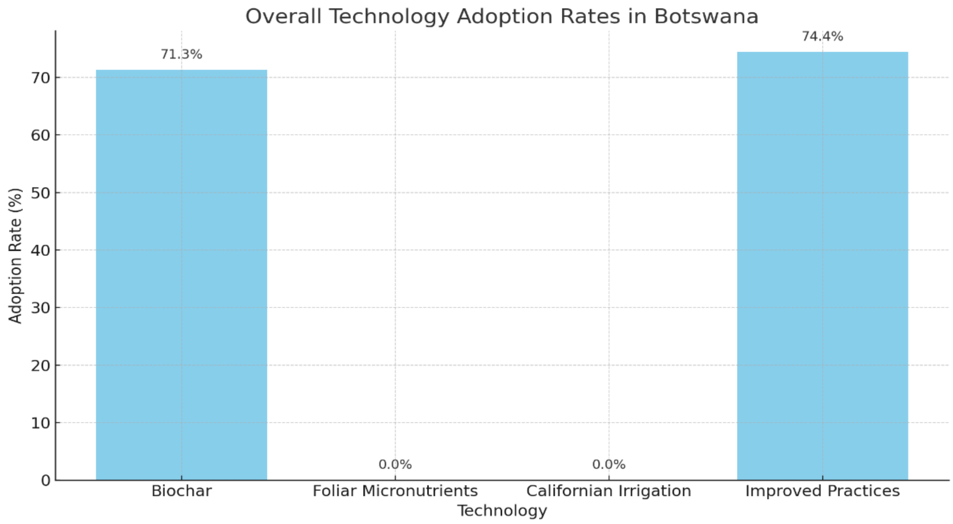

Figure 5.5. Technology adoption rate

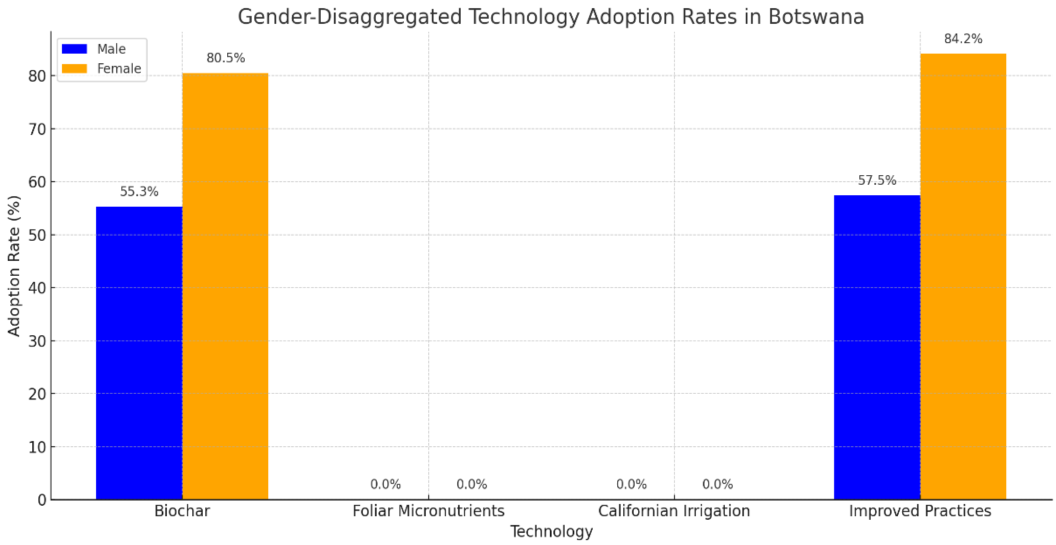

Figure 5.7. Technology adoption rate by gender

5.4. Crops Cultivated Under Technologies and Average Yield Analysis

Farmers in Botswana utilized an average of 1.02 hectares of land for cultivating crops under one or more technologies, with cultivated areas ranging from 0.2 hectares to 3 hectares. This reflects the smallholder nature of farming systems and indicates moderate variability in the land dedicated to these practices. The most common crops cultivated under one or more technologies include Maize (10.08%), Cowpea (7.75%), and Watermelon (6.98%). Other crops, such as Sorghum (2.33%), Pumpkins, Lablab, and Bambara Groundnuts (each 0.78%), were cultivated in smaller proportions. A significant majority (70.54%) of responses were marked as "N/A," suggesting that these farmers either did not cultivate crops beyond those distributed or did not provide additional details.

The focus on maize and cowpea aligns with the project's goal to enhance the adoption of staple crops under climate-resilient technologies. However, the relatively small areas under cultivation and the dominance of "N/A" responses may indicate barriers such as limited resources, risk aversion, or lack of familiarity with the promoted technologies. Further efforts to expand cultivation areas and diversify crop choices could enhance productivity and resilience among smallholder farmers.

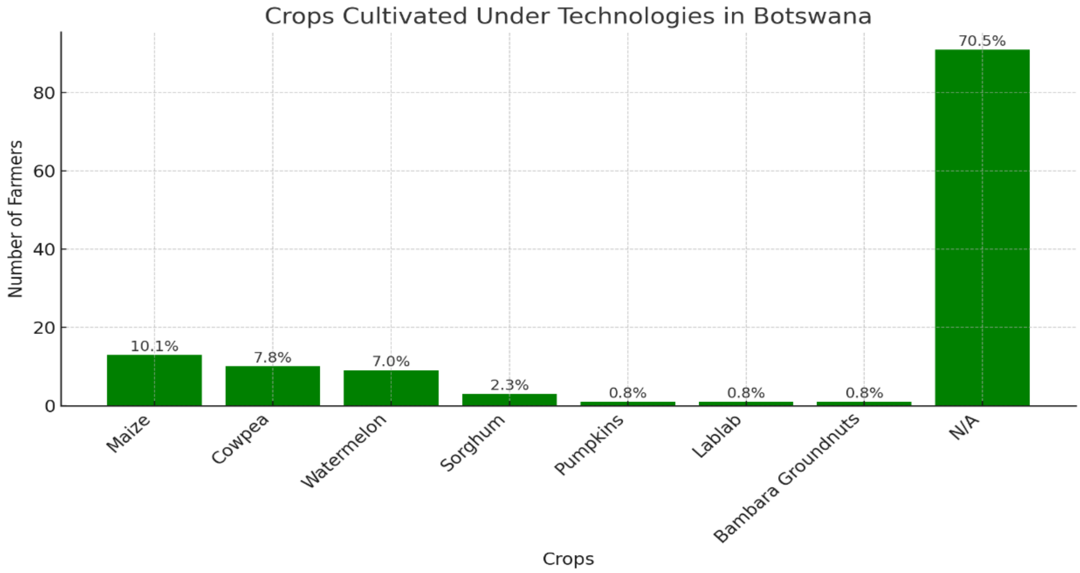

Figure 5.8. Crops cultivated under technologies

5.5. Impact of technology adoption

Overall Yield Insights: The overall average yield across all farmers was **54.87 kg**, with yields ranging from **1 kg** to **1,000 kg**, reflecting considerable variability. The data suggests that technologies like biochar and improved crop management practices contribute significantly to productivity, while the absence of adoption for foliar micronutrients and Californian irrigation systems indicates a missed opportunity for yield improvement.

Yield by Technology Adoption: Farmers who adopted **Biochar** achieved higher average yields (**62.87 kg**) compared to non-adopters (**34.97 kg**), reflecting the effectiveness of this technology in boosting productivity. Adoption of **Improved Crop Management Practices** also led to higher yields, with adopters averaging **58.03 kg**, compared to **45.66 kg** for non-adopters. Farmers who did not use **Foliar Micronutrients** or the **Californian Irrigation System** achieved an average yield of **54.87 kg**, as these technologies were not adopted.

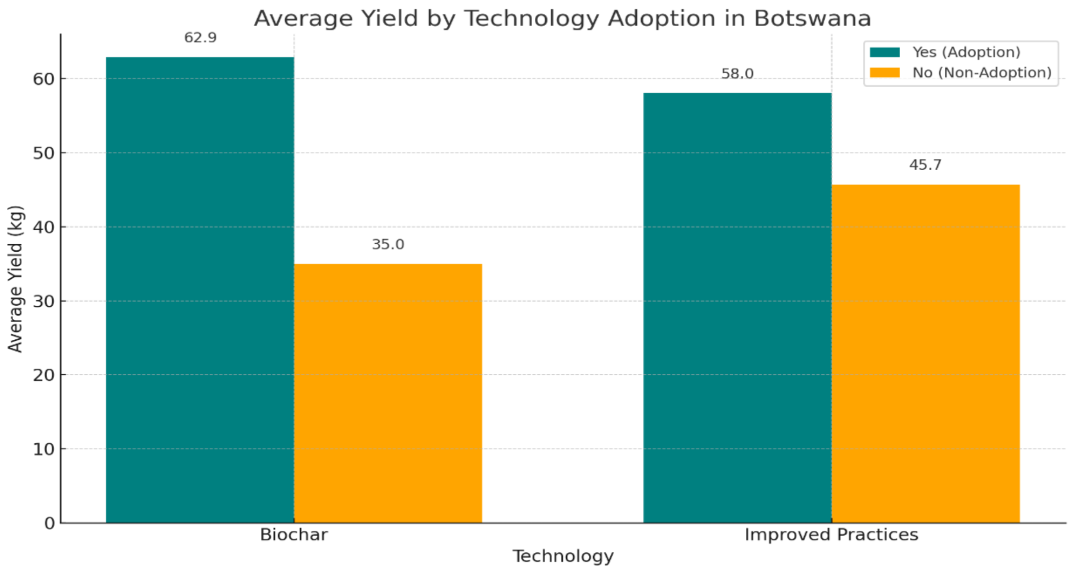

Figure 5.9. Average yield by technology adoption

Yield by Crop Cultivated Under Technologies: The analysis indicates variability in crop yields based on the type of crop cultivated under technologies. **Watermelon** had the highest average yield at **140.86 kg/ha**, with significant variability ranging from **20 kg/ha** to **1,000 kg**. **Maize** followed with an average yield of **60.09 kg/ha**, though yields showed high variability (from **2.25 kg** to **350 kg**). **Cowpeas** averaged **39.46 kg** per farmer, with yields ranging from **2.25 kg/ha** to **100 kg/ha**. Other crops, such as **Bambara Groundnuts**, **Lablab**, **Pumpkins**, and **Sorghum**, each recorded an average yield of **35.39 kg/ha**, though these were based on very few observations, limiting their representativeness.

These results highlight the potential of watermelon and maize for higher productivity under the adopted technologies, while other crops may require targeted interventions to improve their yield potential.

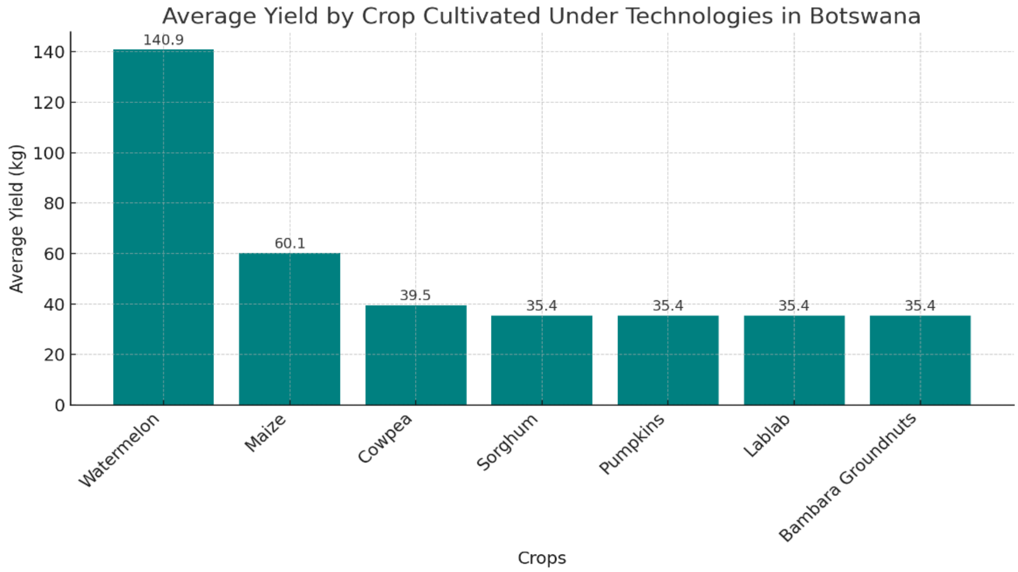

Figure 5.10. Average yield by crop cultivated under technologies

5.6. Interpretation of the results according to the theory of change

The results for Botswana align well with the project's Theory of Change, showing progress through the outlined activities, achieving key outputs, and advancing toward the intended outcomes.

Activities:

Activity 2.4: The development of appropriate training packages tailored to Botswana's context has facilitated farmers' understanding and application of climate-smart technologies. These training materials have been critical in enabling farmers to adopt practices that enhance resilience and productivity.

Activity 2.5: The training of extension workers as facilitators and the operation of Farmer Field Schools of Excellence (FFSE) have ensured hands-on capacity building. This approach has empowered farmers with the necessary skills and confidence to adopt and implement promoted technologies.

Outputs:

Output 3.2.5: Training packages developed for Botswana were adapted to local needs and translated into accessible formats, ensuring inclusivity and widespread dissemination.

Output 3.2.6: Technical guidelines provided to the Ministry of Agriculture have reinforced institutional support for scaling up climate-smart agriculture across the country.

Output 3.2.7: FFSE facilitators trained in Botswana played a pivotal role in engaging farmers, providing consistent knowledge dissemination, and addressing challenges faced in technology adoption.

Output 3.2.8: A significant number of farmers, including 50% women, were trained through FFSE, demonstrating the project's commitment to gender inclusivity and equitable capacity building.

Outcomes:

Adoption of climate-smart technologies is evident, particularly for Biochar and Improved Crop Management Practices, which have shown significant positive impacts on yield. Farmers who adopted biochar achieved an average yield of 62.87 kg, compared to 34.97 kg for non-adopters, while those using improved crop management practices recorded an average yield of 58.03 kg, against 45.66 kg for non-adopters. These results underscore the technologies' relevance and effectiveness in Botswana. The engagement of female farmers has been especially noteworthy, with women adopting the promoted technologies at higher rates than men, contributing to household food security and resilience.

Key Challenges and Recommendations: The lack of adoption for Foliar Micronutrients and the Californian Irrigation System highlights barriers such as accessibility, affordability, or relevance. Addressing these challenges through targeted interventions or alternative solutions could unlock additional productivity gains. Crop yields, such as those for Watermelon (140.86 kg) and Maize (60.09 kg), demonstrate the potential for high productivity under promoted technologies. However, the lower yields for crops like Cowpea (39.46 kg) and Sorghum (35.39 kg) suggest the need for further research and training to enhance their performance.

Theory of Change Alignment:

The activities and outputs in Botswana are strongly aligned with the project's Theory of Change, contributing to the broader goal of reaching up to 11,550 farmers across six countries. The high adoption rates and productivity outcomes validate the effectiveness of the project's strategies in improving agricultural resilience and food security. By continuing to address barriers, promote gender inclusivity, and scale up successful practices, the project in Botswana is well-positioned to achieve its long-term outcomes.

In summary, the project has made significant progress in Botswana by equipping farmers with climate-smart technologies, improving yields, and fostering gender equity. To maximize impact, efforts should focus on addressing barriers to underutilized technologies, enhancing crop diversification, and strengthening capacity-building initiatives.

VI. Country: Gambia

6.1. Demographic analysis

The survey conducted in Gambia involved 730 respondents, all of whom contributed to understanding the demographic, geographic, and cooperative dynamics of agricultural practices in the region. Gender analysis reveals that women account for 91.64% of the respondents, indicating significant female participation in agricultural activities, aligned with the project's focus on gender inclusion. Male respondents constitute 8.36%, demonstrating a gender representation that emphasizes women's critical role in the sector.

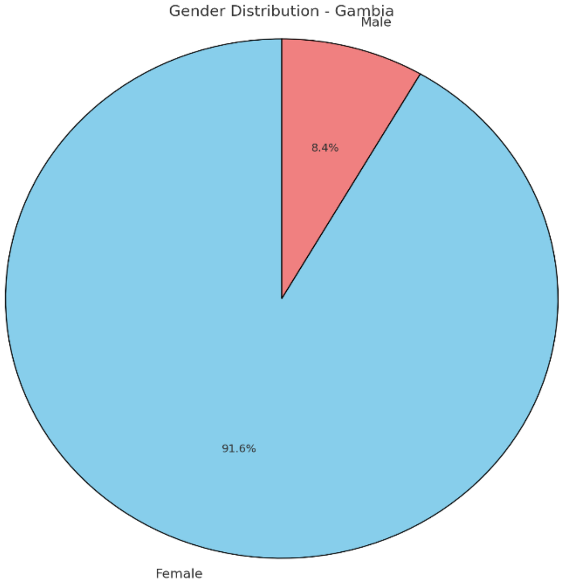

Figure 6 .1.Gender distribution

The analysis of village representation shows that Gengi Wollof is the most represented village, with 43.56% of respondents, followed by Jahaur Mandinka at 28.49%. Batti Youngo contributes 13.42%, while Kerewan Sitokoto and Darsilameh account for 12.60% and 1.92%, respectively. This distribution suggests a strong project presence in major villages like Gengi Wollof and Jahaur Mandinka, with opportunities to further strengthen engagement in less represented areas.

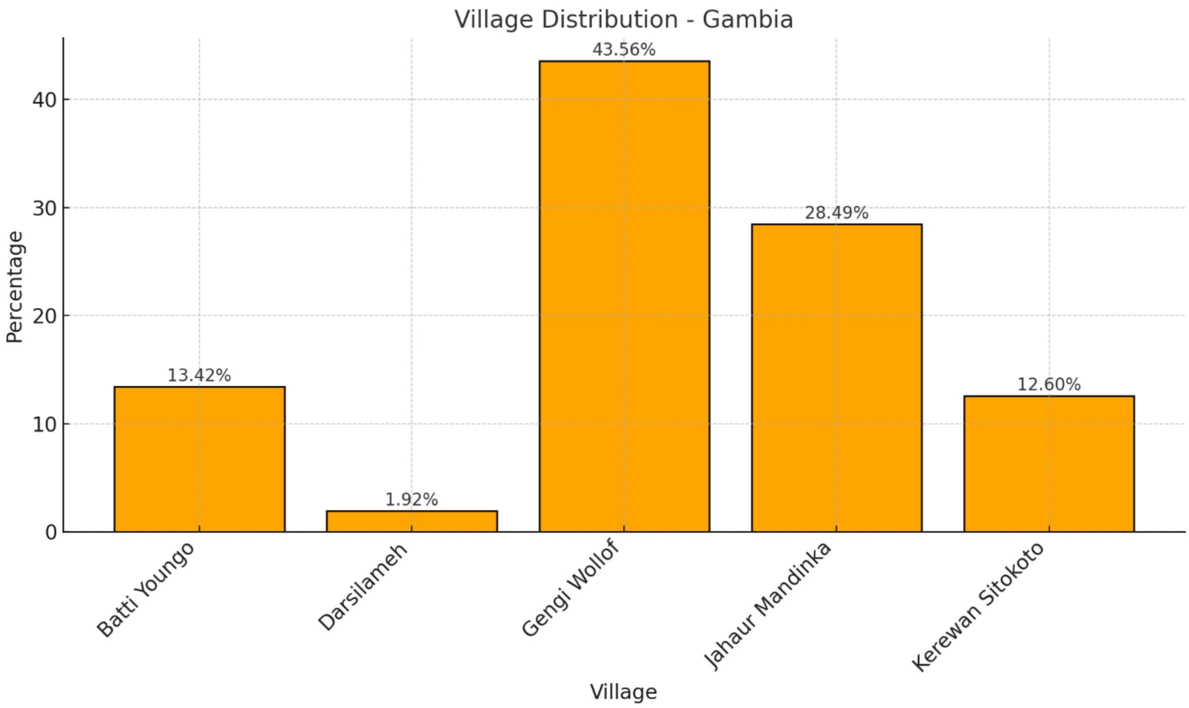

Figure 6.2. Village distribution

Regarding cooperative participation, Gengi Wollof Cooperative emerges as the most engaged, with 43.56% of respondents, indicating its pivotal role in the project's implementation. Jahaur Mandinka Cooperative follows with 28.49%, and Batti Youngo Cooperative with 13.42%. Kerewan Sitokoto Cooperative accounts for 12.60%, while individual farmers represent 1.92%. This analysis highlights the importance of cooperatives in mobilizing farmers and suggests targeted support for smaller cooperatives to increase their impact.

The summary statistics for total farming area (ha) reveal an average farm size of 0.112 hectares, emphasizing the smallholder nature of agricultural systems in Gambia. The standard deviation of 0.584 hectares reflects considerable variability in landholdings, with some farmers cultivating as little as 0.01 hectares and others up to 5 hectares. These findings underscore the need for interventions tailored to small-scale farming systems while supporting those with larger holdings to maximize productivity.

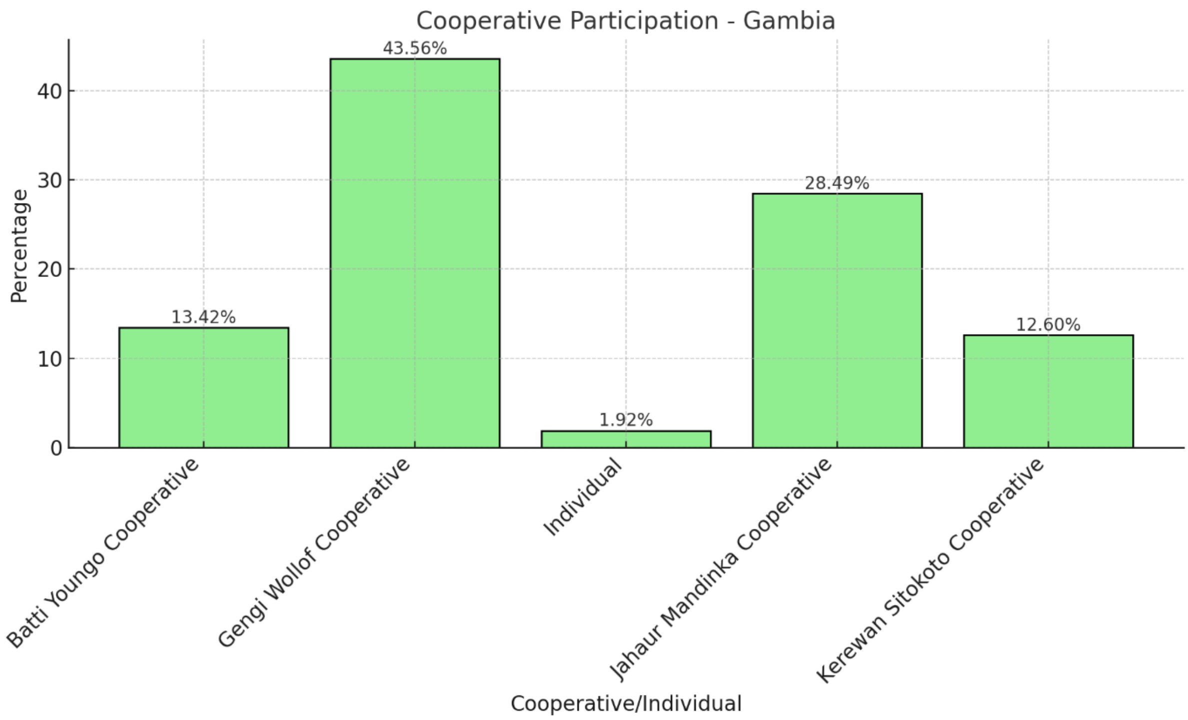

Figure 6.3.Cooperative participation

6.2. Crop basket

The technologies adopters survey results in Gambia show that Cowpea is the most distributed crop (56.71%), followed by Sorghum (28.77%) and Pearl Millet (14.52%), emphasizing climate-resilient crops. ILRI 9334 (28.49%) and ILRI 9643 (28.22%) are the predominant varieties, with smaller shares for ICSR-93034, ICSV-700 (14.38% each), IP 19586, and MC 94 (7.26% each). These findings suggest a strategic focus on resilient varieties, although the lower distribution of certain varieties may reflect either specific targeting or limited availability. Most farmers (60.92%) received small quantities (0.0005 kg), with 18.77% and 17.62% receiving 0.6 kg and 0.65 kg, respectively. These results reflect a phased distribution approach, focusing on resilient crops and equitable access.

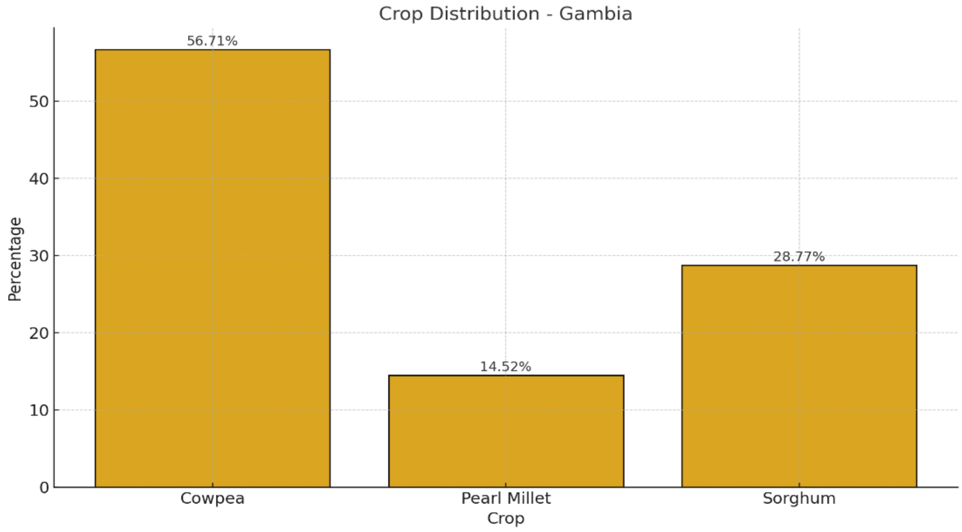

Figure 6.4. Crop varieties distributed

The distribution of crop varieties across the three main crops including Cowpea, Pearl Millet, and Sorghum reveals a targeted allocation strategy. Cowpea is predominantly associated with ILRI 9334 (208 instances) and ILRI 9643 (206 instances), indicating a strong focus on these resilient varieties. Pearl Millet is evenly distributed between IP 19586 and MC 94, with 53 instances each, reflecting diversification efforts within this crop. Sorghum, on the other hand, is exclusively linked to ICSR-93034 and ICSV-700, with 105 instances each, demonstrating a concentrated promotion of these specific varieties. This distribution strategy aligns with the project's objective of providing farmers with crop varieties best suited to their environmental conditions and agricultural needs.

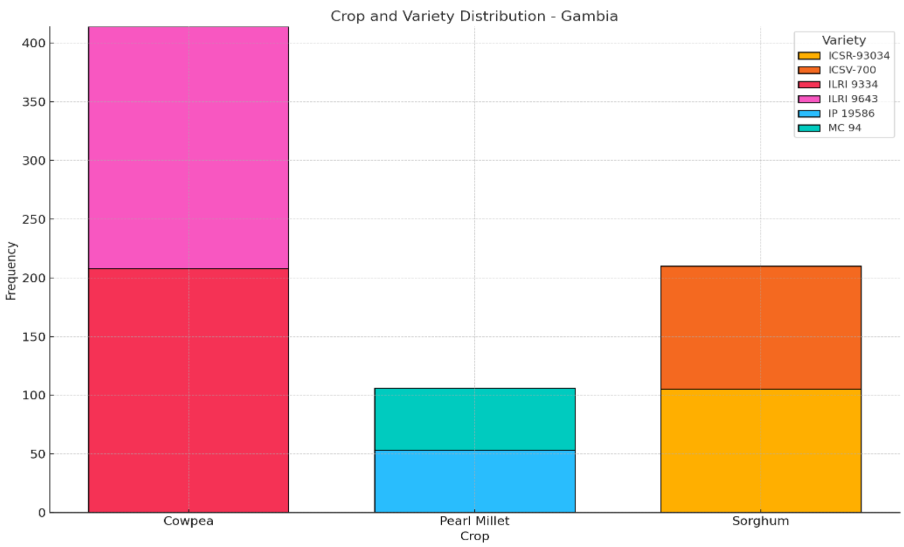

Figure 6.5 Crop varieties distribution

6.3. Technologies adopted and surface cultivated

The technology adoption rate analysis for Gambia highlights the following key findings:

- **Biochar:** A high adoption rate of **98.08%** is observed overall. Disaggregated by gender, **99.55%** of female respondents and 81.97% of male respondents reported adopting Biochar, indicating its broad acceptance and relevance, particularly among women.
- **Foliar Micronutrients:** Adoption is absent across all respondents, with both male and female farmers reporting 0% usage. This suggests barriers such as cost, availability, or lack of alignment with farmers' needs.
- **Californian Irrigation System:** Similarly, no adoption is recorded (0%) for both genders, pointing to possible inaccessibility or unsuitability of this technology for local farming conditions.
- **Improved Crop Management Practices:** Adoption is widespread, with **98.08%** of all respondents implementing these practices. Female farmers show a near-universal adoption rate of **99.55%, while 81.97%** of male farmers report adoption, underscoring the accessibility and effectiveness of these practices.
- **Other Technologies**: No respondents reported using any additional technologies, highlighting the focused promotion of the core project technologies.

These results indicate a strong alignment of Biochar and improved crop management practices with farmers' needs, while other technologies face barriers to adoption. Targeted interventions are needed to address these gaps and promote underutilized technologies.

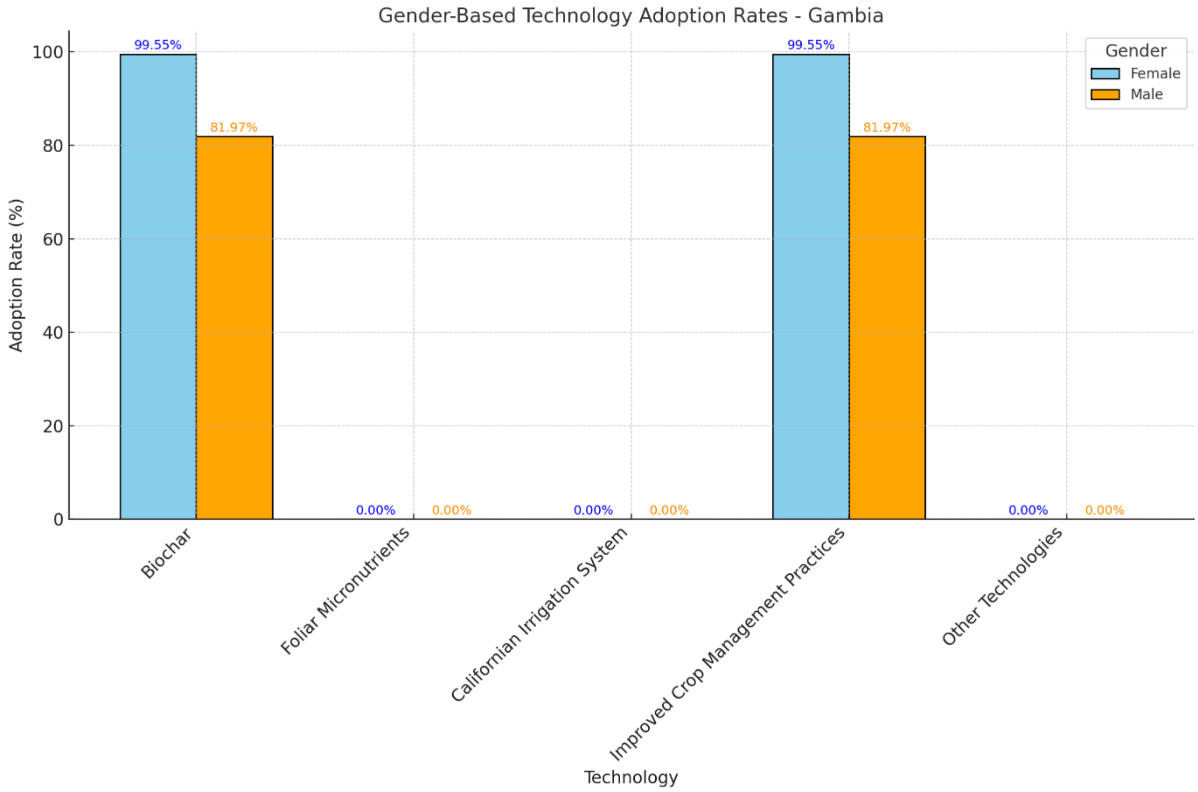

Figure 6.6. Technology adoption rate by gender

6.4. Crops Cultivated Under Technologies and Average Yield Analysis

The analysis of surface areas cultivated under technologies in Gambia highlights the smallholder nature of farming systems. The average area cultivated is only 0.0021 hectares, with a maximum of 0.25 hectares, reflecting limited land availability and cautious adoption of new technologies. This suggests that farmers are testing these practices on smaller plots, likely due to resource constraints or risk aversion.

Regarding crops cultivated under technologies, ILRI 9334 (28.49%) and ILRI 9643 (28.22%) dominate, indicating a strong preference for these resilient and high-performing varieties. ICSR-93034 and ICSV-700 account for 14.38% each, while IP 19586 and MC 94 represent 7.26% each. This distribution reflects a strategic focus on proven varieties suited to local conditions, ensuring that the promoted technologies align with the farmers' needs and environmental contexts.

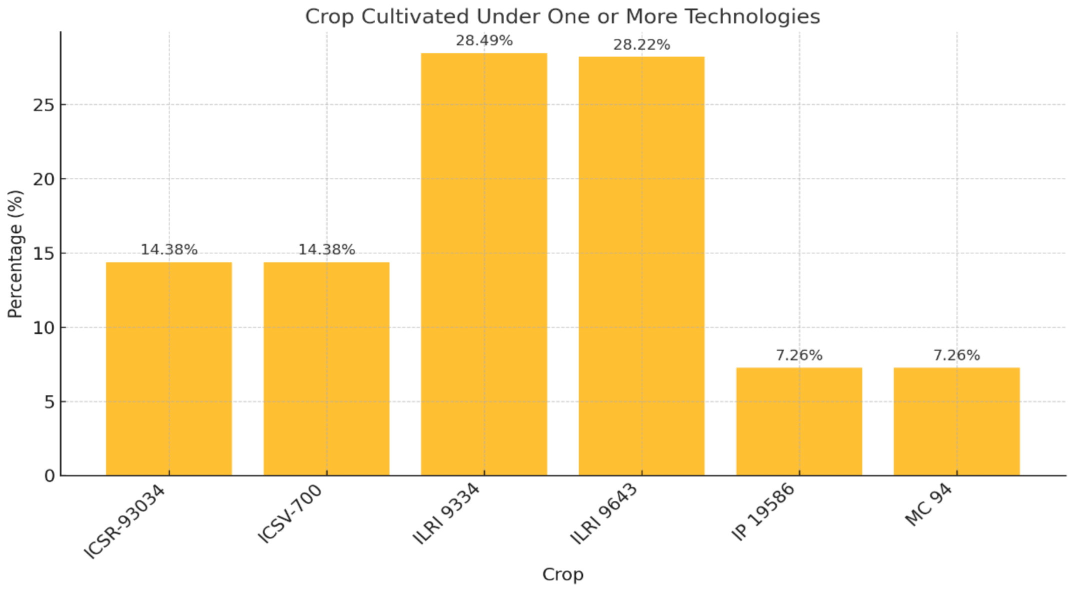

Figure 6.7. Crop cultivated rate under technology

6.5. Impact of technology adoption on yields

Average yield by technology adoption

The analysis of average yields by technology adoption reveals that farmers who adopted Biochar and Improved Crop Management Practices achieved average yields of 0.052 kg/ha, indicating modest gains. In contrast, non-adopters of these technologies achieved significantly higher average yields of 21.57 kg/ha, suggesting that factors such as soil quality, crop type, or other farming practices may be influencing these outcomes. No yields were recorded for adopters of Foliar Micronutrients or Californian Irrigation Systems due to zero adoption, while non-adopters of these technologies showed average yields of 0.46 kg/ha. These findings highlight the need to explore barriers to adoption and investigate other factors contributing to the higher yields among non-adopters to better align technology interventions with farmers’ needs and conditions.

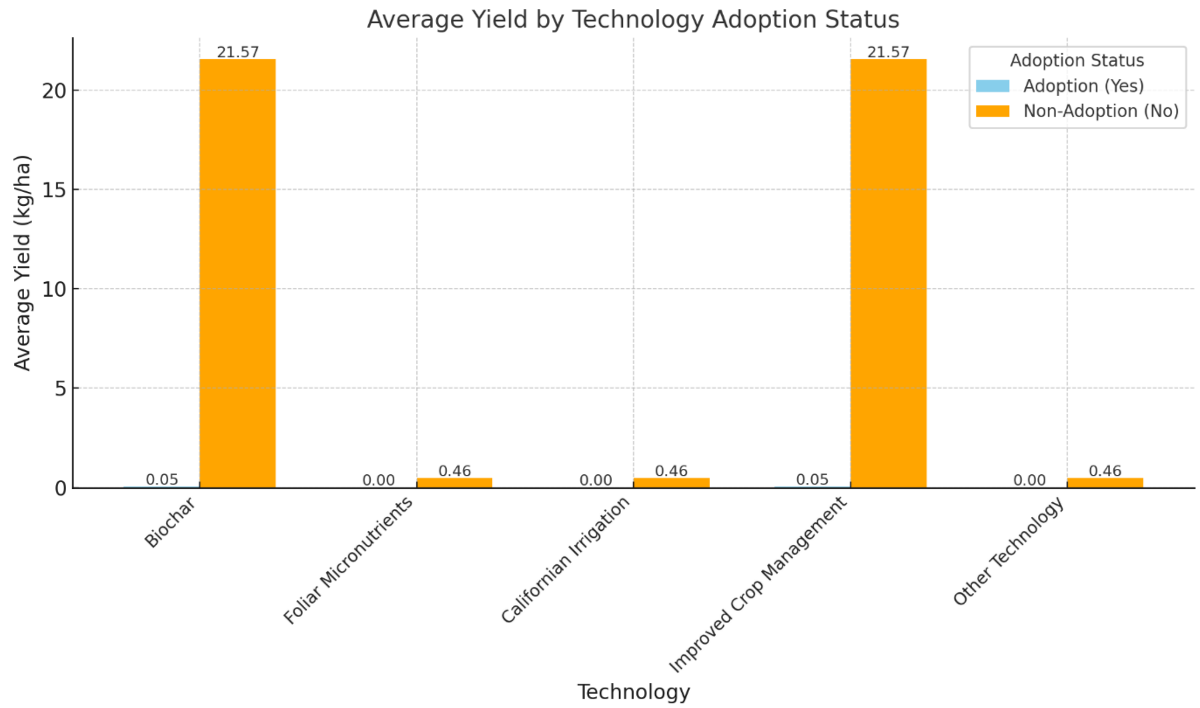

Figure 6.8. Average yield by technology adoption

Average yield by crop seed distributed

The analysis of average yields for crops distributed as seeds reveals distinct variations in productivity. Cowpea achieved an average yield of **0.81 kg/ha**, indicating its relatively strong performance under the distributed technologies and favorable adaptation to the existing conditions. Sorghum recorded a significantly lower average yield of **0.019 kg/ha**, reflecting challenges in productivity and potentially suboptimal conditions for its cultivation. Pearl Millet, with an average yield of **0.0065 kg/ha**, exhibited the lowest productivity among the crops, suggesting limited adaptability or the need for improved cultivation practices and inputs.

These findings emphasize the need to focus on high-performing crops like Cowpea while identifying opportunities to improve the yields of Sorghum and Pearl Millet through targeted research, enhanced farming practices, and better resource allocation.

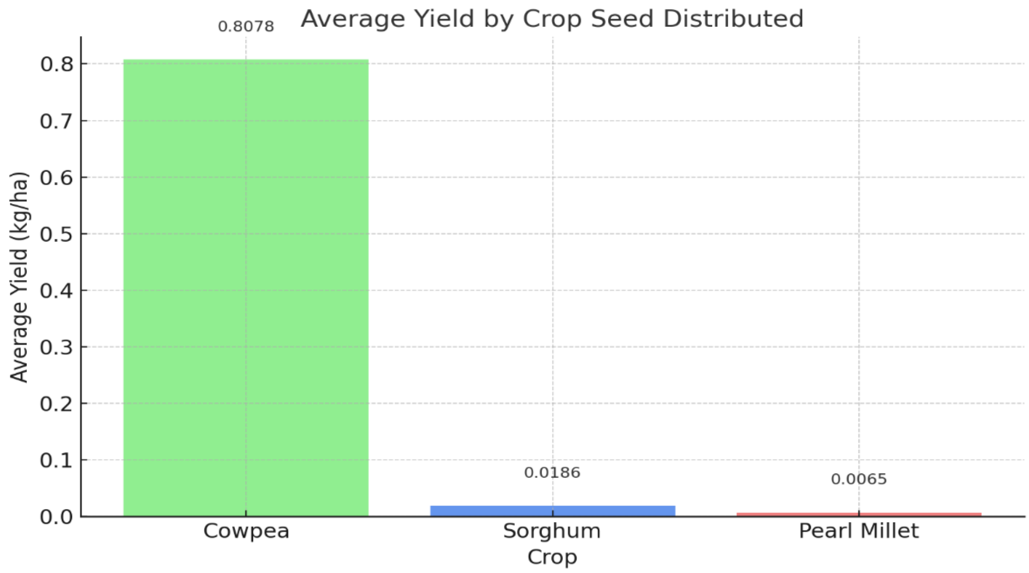

Figure 6.9. Average yield by crop seed distributed

Average yield by other crops cultivated under one or more technology

The analysis of average yields for crops cultivated under one or more technologies reveals notable differences in productivity. **ILRI 9334** achieved the highest average yield of **0.90 kg/ha**, demonstrating its strong adaptability and suitability to the applied technologies. Similarly, **ILRI 9643** recorded a relatively high average yield of **0.71 kg/ha**, reflecting its potential for improved productivity. In contrast, **ICSV-700** and **ICSR-93034** exhibited much lower average yields of **0.026 kg/ha** and **0.011 kg/ha**, respectively, indicating possible limitations in cultivation conditions or technology application. **IP 19586** and **MC 94** recorded the lowest yields of **0.007 kg/ha** and **0.006 kg/ha**, respectively, suggesting significant challenges in their production.

These findings highlight the need to focus on high-performing crops like ILRI 9334 and ILRI 9643 varieties while addressing the constraints faced by lower-yielding crops such as ICSV-700 and ICSR-93034 varieties through tailored interventions and improved practices to enhance overall agricultural outcomes.

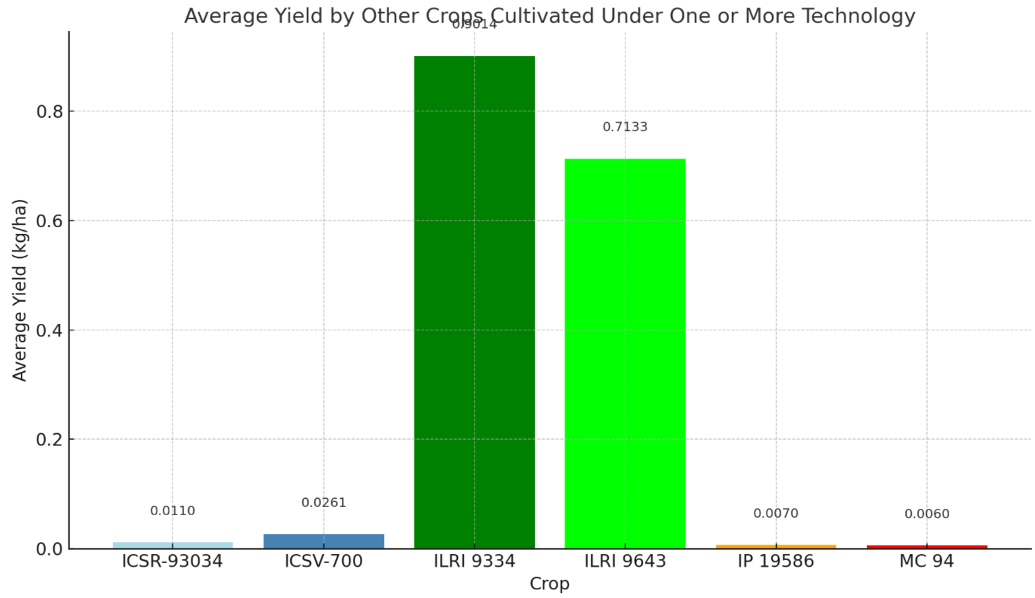

Figure 6.10. Average yield by other crops cultivated under one or more technology

6.6. Theory of Change Interpretation for Gambia County

Activities

Activity 2.4 (Development of Training Packages): Training materials were developed and translated into local languages, addressing the literacy needs of participants and ensuring accessibility for women, who represent 91.64% of respondents in Gambia. This aligns with the project's goal of gender inclusion and empowering women farmers.

Activity 2.5 (Training of Trainers and Farmer Field Schools of Excellence): The training of facilitators and the subsequent establishment of Farmer Field Schools directly supported the high adoption rates of key technologies, such as Biochar (98.08%) and Improved Crop Management Practices (98.08%). These activities ensured that technical knowledge and practical skills reached farmers effectively, reflected in widespread adoption despite small landholding sizes.

Outputs

3.2.5 & 3.2.6 (Training Packages and Guidelines Development): The distribution of translated technical materials facilitated high engagement in the targeted areas. Cooperatives like Gengi Wollof (43.56% participation) and Jahaur Mandinka (28.49%) became hubs for disseminating knowledge, enabling broader reach and application of the training.

3.2.7 & 3.2.8 (Training FFSE Facilitators and Farmers): Training outcomes are evident in the adoption rates of Biochar and Improved Crop Management Practices, where 99.55% of female farmers utilized these technologies. The training likely influenced the strategic allocation of resilient crop varieties (e.g., ILRI 9334 and ILRI 9643), which were cultivated by 28.49% and 28.22% of farmers, respectively, reinforcing the link between training and adoption.

Outcomes

Adoption of Cropping Systems and Technologies: The project's activities resulted in high adoption rates for Biochar and Improved Crop Management Practices, but other technologies like Foliar

Micronutrients and Californian Irrigation Systems saw no uptake. These gaps suggest a need to tailor interventions and address barriers like cost or unsuitability to local conditions. However, challenges remain with yield outcomes. Adopters of Biochar and Improved Crop Management achieved modest yields (0.052 kg/ha), lower than non-adopters (21.57 kg/ha), indicating that technology adoption alone does not guarantee improved productivity. Factors such as soil conditions, resource availability, and crop type may require further attention to achieve the desired outcomes.

Crop-Specific Outcomes: Cowpea performed well under distributed technologies, achieving an average yield of 0.81 kg/ha. Sorghum (0.019 kg/ha) and Pearl Millet (0.0065 kg/ha) underperformed, necessitating research and interventions to enhance their productivity. For crops cultivated under technologies, ILRI 9334 and ILRI 9643 achieved the highest yields (0.90 and 0.71 kg/ha), validating their suitability to Gambia's conditions. Conversely, ICSV-700, ICSR-93034, IP 19586, and MC 94 struggled, indicating the need for tailored support for these varieties.

Alignment with the Theory of Change

The results align with the Theory of Change, demonstrating significant progress in building farmer capacity and promoting technology adoption. However, the disparity in yield outcomes underscores the complexity of translating adoption into productivity gains. To fully realize the project's goals:

- Further refine training to address yield gaps through advanced techniques and tailored support.
- Investigate and mitigate barriers to the adoption of non-utilized technologies.
- Strengthen the support for underperforming crops and varieties while scaling up the success of high-performing ones like ILRI 9334 and ILRI 9643.

These steps will help ensure that the project achieves its intended outcomes, including the adoption of improved practices by 11,550 farmers and enhanced agricultural resilience in salinity-affected areas of Gambia.