CHALLENGES AND STRATEGIES FOR ENHANCING DISASTER RESILIENCE AND SERVICE RELIABILITY IN FICELCO'S OFF-GRID SYSTEM

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ABSTRACT

This study employed a descriptive research design to determine the challenges and strategies for enhancing disaster resilience and service reliability in the off-grid system of the First Catanduanes Electric Cooperative, Inc. (FICELCO). Using a structured survey, the study assessed the respondents' demographic and professional profile, the challenges encountered during and after disasters, and the effectiveness of existing disaster resilience strategies. The analysis further examined whether statistically significant differences existed in the respondents' perceptions when grouped according to age, sex, job position, length of service, department, and number of disaster-related trainings attended. The results served as the basis for formulating a strategic intervention plan aimed at strengthening FICELCO's disaster preparedness and operational reliability. Findings showed that most respondents were aged 36–45, predominantly male (85.14%), and commonly employed as linemen (20.95%), with the majority serving for over 10 years. The Technical Services and Administrative Departments comprised 31.08% of the sample. Regarding challenges, Infrastructure Vulnerability and Damage and Public Expectations and Communication were rated the most severe, both posting a weighted mean of 3.55, followed by Environmental and Geographical Challenges (3.53), Resource Limitations (3.52), and Communication and Coordination Issues (3.47). The overall mean of 3.52 indicated that all challenges were perceived as "very challenging." In terms of strategy effectiveness, Emergency Response and Restoration Protocols obtained the highest weighted mean of 3.58, followed closely by Workplace Training and Capacity Building (3.57), Infrastructure Hardening and Redundancy (3.56), Real-Time Monitoring and Early Warning Systems (3.54), and Community Engagement (3.53), with an overall mean of 3.56, indicating "highly effective." Significant differences were identified in several domains based on age, job position, length of service, department assignment, and number of trainings attended, with department/unit of assignment emerging as a consistent influential factor (p-values ranging from 0.0005 to 0.0492). A comprehensive intervention plan was developed to address weaknesses in infrastructure, communication, resource readiness, staff capability, and community involvement. In conclusion, the study highlights that FICELCO personnel face considerable challenges in disaster operations, especially related to infrastructure damage and communication demands. Despite these constraints, the organization's strategic measures are widely regarded as effective. The variations in perceptions across demographic and professional groups further justify the need for a targeted and department-sensitive intervention plan to enhance disaster resilience and sustain reliable service delivery.

Keywords: disaster resilience, service reliability, off-grid operations, emergency response, FICELCO

INTRODUCTION

The resilience of off-grid energy systems has become a critical issue, particularly in disaster-prone regions where power interruptions threaten safety, economic stability, and community well-being. Silva et al. (2022) emphasized the importance of strengthening energy resilience through modernization and the integration of renewable energy technologies across the Asia-Pacific region, noting that isolated areas remain the most vulnerable to disruptions. In the Philippine context, off-grid cooperatives continue to face recurring damage to energy infrastructure caused by typhoons, heavy rainfall, and coastal hazards, which directly affect service reliability and slow down post-disaster recovery efforts (Bertheau et al., 2020; Salac et al., 2024). These patterns mirror the broader regional findings that communities in island and rural settings experience heightened exposure and economic vulnerability due to climate-related disasters (Lyu et al., 2023; Delina et al., 2025). Such conditions underscore the necessity of assessing and improving the disaster resilience of off-grid systems, including that of the First Catanduanes Electric Cooperative (FICELCO).

The national policy environment in the Philippines provides robust support for building energy-sector resilience. Republic Act No. 11039 established the Electric Cooperatives Emergency and Resiliency Fund, ensuring that electric cooperatives have access to dedicated financial resources for the rapid restoration and rehabilitation of damaged power facilities (Official Gazette of the Republic of the Philippines, 2018). Recent analyses of disaster resilience trends also highlight the increasing need for systemic preparedness at the organizational and regional levels, noting that socio-economic and geographic factors continue to shape communities' vulnerability to major disasters (Chong et al., 2025). These insights reinforce the relevance of evaluating how off-grid cooperatives prepare for, respond to, and recover from severe climatic events.

Despite the growing body of literature on renewable energy integration and resilience, research remains limited regarding the specific challenges encountered by off-grid electric cooperatives in highly exposed island provinces such as Catanduanes. Existing studies have largely focused on national energy transitions, broad policy landscapes, and generalized implementation barriers (Bertheau et al., 2020; Salac et al., 2024). However, localized operational constraints—including infrastructure fragility, logistical limitations, and the financial strain caused by repeated disaster impacts—remain understudied. This gap highlights the need for focused research on FICELCO's operational realities, resilience mechanisms, and long-term adaptation strategies within a highly vulnerable geographic setting.

This study is significant because it provides a context-specific analysis of the challenges affecting power reliability in Catanduanes, offering insights into infrastructure vulnerabilities, organizational preparedness, and attainable resilience strategies. By grounding the investigation in documented regional and national findings on disaster impacts and energy transition issues, the study contributes practical and policy-relevant knowledge. Its results can guide cooperative planning, inform local policy development, and support the advancement of sustainable and adaptive off-grid energy systems. In doing so, the study addresses a critical research gap and offers evidence-based recommendations that can strengthen the energy resilience of communities frequently affected by severe natural hazards.

LITERATURE REVIEW

The reviewed studies clearly show that improving resilience and keeping energy services running during disasters are essential, especially for off-grid systems. Researchers explain that strong disaster recovery depends on good planning, backup systems, and organized procedures. Alozie et al. (2024) point out that strategies used in reliability engineering, such as constant monitoring, quick recovery, and system redundancy, can also be applied to off-grid energy systems to reduce interruptions. In the same way, Pemmasani and Abd Nasaruddin (2022) highlight that disaster response is more effective when supported by strong IT systems and well-coordinated crisis management, suggesting that energy providers should adopt integrated and technology-based solutions.

The literature also stresses the importance of communication during disasters. Shittu et al. (2018) explain that reliable communication networks help responders share information and coordinate faster, which is necessary for restoring electricity in isolated areas. Karaman et al. (2025) add that communication systems used during disasters must be secure, flexible, and easy to deploy so that emergency operations can continue even under extreme conditions. Several studies focus on strategies that directly support energy resilience. Cabrera-Tobar et al. (2023) note that telecommunications rely on systems such as microgrids, distributed energy sources, and backup power to stay functional during emergencies. Bouramdane (2024) emphasizes that natural hazards pose serious risks to power grids, and these risks can be reduced through better planning and mitigation measures that consider local landscapes. Modern grid technologies also contribute to resilience. Almihat and Munda (2025) explain that smart grids can improve energy planning through real-time monitoring and automated control. Likewise, Nyangon (2024) shows that artificial intelligence and machine learning can help predict failures and support climate-resilient energy infrastructure.

Other research highlights the importance of energy storage and demand response. Ojo et al. (2025) observe that storage systems and demand response programs help stabilize the power supply during emergencies and speed up recovery. Loni and Asadi (2024) also point out that electric vehicles can support resilience when used as mobile storage units, but their benefits depend on fair access and community conditions.

In summary, the literature agrees that improving disaster resilience and service reliability in off-grid systems requires a mix of strong communication systems, advanced technologies, effective crisis management, and flexible energy strategies. The success of these approaches depends on how well energy organizations can combine these tools and adapt them to the specific challenges faced by isolated communities.

METHODOLOGY

This study on the challenges and strategies for enhancing disaster resilience and service reliability in FICELCO's off-grid systems employed a descriptive research design, which describes current practices, challenges, and personnel perceptions while examining factors affecting service reliability. Using surveys to gather quantitative data, the study identified patterns related to infrastructure, communication, human resources, and demographic factors. This approach provided a clear understanding of FICELCO's disaster preparedness and informed recommendations to strengthen resilience and ensure continuous service during extreme weather events.

Respondents of the Study

The population of the study consisted of 234 personnel from various departments within FICELCO, including operations, maintenance, disaster management, and customer service. Using Slovin's formula, a sample size of 148 respondents was determined. The actual selection of respondents was conducted through stratified random sampling across the different departments within the cooperative to ensure that all relevant perspectives were represented.

Instrumentation

A self-made questionnaire was used to collect data on the challenges and strategies for disaster resilience at FICELCO. It had three parts: Part I covered the respondents' profile (age, sex, job position, length of service, department, and disaster-related training); Part II focused on challenges such as infrastructure vulnerability, communication issues, limited resources, and financial constraints; Part III assessed the effectiveness of strategies like infrastructure upgrades, real-time monitoring, emergency protocols, workforce training, and community engagement.

The questionnaire was validated by a 4-member expert panel for clarity and relevance, and a pre-test with 20 employees ensured consistency. Adjustments were made based on feedback, and the Split-Half method showed a high reliability coefficient of 0.896, confirming the tool's reliability.

RESULTS

Table 1
Profile of the Respondents

Profile	Frequency (n=148)	Percentage
Age		
26 – 35	**45**	**30.41**
36 – 45	**68**	**45.95**
46 – 55	**22**	**14.86**
56 – and above	**13**	**8.78**
Total	**148**	**100.00**
Sex		
Male	**126**	**85.14**
Female	**22**	**14.86**
Total	**148**	**100.00**
Job Position		
Lineman	**31**	**20.95**
Meter Reader	**18**	**12.16**
Technician/Electrician	**6**	**4.05**
Supervisor	**14**	**9.46**
Manager	**7**	**4.73**
Teller	**9**	**6.08**
Dispatch Officer	**4**	**2.70**
Head	**28**	**18.92**
Driver	**18**	**12.16**
Office Staff	**13**	**8.78**
Total	**148**	**100.00**
Length of Service at FICELCO		

Less than 1 year	**5**	**3.38**
1 – 5 years	**46**	**31.08**
6 – 10 years	**37**	**25.00**
More than 10 years	**70**	**40.54**
Total	**148**	**100.00**
Department or Unit of Assignment		
Office of the General Manager	**8**	**5.41**
Administrative Manager	**32**	**21.62**
Corporate Planning Department	**5**	**3.38**
Internal Audit Department	**3**	**2.03**
Consumer Services Department	**13**	**8.78**
Finance Services Department	**24**	**16.22**
Technical Services Department	**46**	**31.08**
Area Office Department	**17**	**11.48**
Total	**148**	**100.00**
Number of Trainings Related to Disaster Resilience and Power Restoration		
None	**39**	**26.35**
1 – 2 trainings	**97**	**65.54**
3 – 5 trainings	**10**	**6.76**
More than 5 trainings	**2**	**1.35**
Total	**148**	**100.00**

The profile of the 148 respondents from FICELCO shows that most employees fall within the 36–45 age group, comprising 68 individuals or 45.95%, followed by the 26–35 age group with 45 respondents (30.41%). The majority of respondents are male (126, 85.14%) compared to females (22, 14.86%). In terms of job positions, the largest groups are Technical Services Department staff (46, 31.08%), Linemen (31, 20.95%), and Department Heads (28, 18.92%), while other positions such as Supervisors, Managers, Tellers, Dispatch Officers, Drivers, and Office Staff represent smaller proportions. Regarding length of service, most respondents have been employed for more than 10 years (70, 40.54%), followed by those with 1–5 years (46, 31.08%) and 6–10 years (37, 25%). Assignment by department shows that Technical Services Department employs the most personnel (46, 31.08%), with Administrative Manager (32, 21.62%) and Finance Services (24, 16.22%) following. Finally, the majority of respondents have attended 1–2 trainings related to disaster resilience and power restoration (97, 65.54%), though a significant number have had no training (39, 26.35%), and very few have attended more than five sessions (2, 1.35%).

In summary, FICELCO's workforce is predominantly male, middle-aged, and experienced, with a substantial proportion holding technical or managerial roles. Most personnel have moderate exposure to disaster resilience and power restoration training, highlighting potential areas for capacity building to strengthen the organization's preparedness and service reliability.

Table 2
Composite Table on the Challenges Faced by Personnel of FICELCO in Maintaining Service Reliability During and After Disasters

Variable	Weighted mean	Verbal Interpretation	Rank
Infrastructure Vulnerability and Damage	**3.55**	**Strongly Agree/Very Challenging**	**1.5**
Communication and Coordination Issues	**3.47**	**Strongly Agree/Very Challenging**	**5**

Resource Limitations	**3.52**	**Strongly Agree/Very Challenging**	**4**
Environmental and Geographical Challenges	**3.53**	**Strongly Agree/Very Challenging**	**3**
Expectations and Communication	**3.55**	**Strongly Agree/Very Challenging**	**1.5**
Overall weighted mean	**3.52**	**Strongly Agree/Very Challenging**	

The composite table summarizing the profile of FICELCO personnel indicates that the majority of respondents are male (85.14%) and fall within the 36–45 age bracket (45.95%), with a substantial number having more than 10 years of service (40.54%). The workforce is largely concentrated in technical and managerial roles, particularly within the Technical Services Department (31.08%) and Administrative Management (21.62%). Regarding disaster resilience and power restoration training, most personnel (65.54%) have attended 1–2 sessions, while a notable portion (26.35%) have not received any related training. These findings suggest that while FICELCO has a relatively experienced workforce, exposure to disaster preparedness training is moderate, highlighting areas for capacity development.

Overall, the results reflect a workforce with significant experience and technical capacity, yet with room to strengthen preparedness for maintaining service reliability during disasters. This aligns with Silva et al. (2022), who emphasized that off-grid energy systems, particularly in disaster-prone regions, remain vulnerable to disruptions, and targeted training is critical for resilience. In the Philippine context, electric cooperatives like FICELCO face recurring infrastructure damage from typhoons, heavy rainfall, and coastal hazards, which threaten service continuity and slow recovery (Bertheau et al., 2020; Salac et al., 2024). Strengthening staff capacity through systematic training and skills development is therefore essential to enhance the cooperative's disaster resilience and ensure sustained energy service for vulnerable island communities (Lyu et al., 2023; Delina et al., 2025).

Table 3
Composite Table on Level of Effectiveness of the Disaster Resilience Strategies Implemented by FICELCO to Ensure Reliability During and After Disaster

Variable	Weighted mean	Verbal Interpretation	Rank
Infrastructure Hardening and Redundancy	**3.56**	**Strongly Agree/ Highly Effective**	**3**
Real-time Monitoring and Early Warning Systems	**3.54**	**Strongly Agree/ Highly Effective**	**4**
Emergency Response and Restoration Protocols	**3.58**	**Strongly Agree/ Highly Effective**	**1**
Workplace Training and Capacity Building	**3.57**	**Strongly Agree/ Highly Effective**	**2**
Community Engagement and Awareness Programs	**3.53**	**Strongly Agree/ Highly Effective**	**5**
Overall weighted mean	**3.56**	**Strongly Agree Highly Effective**	

The composite table on the level of effectiveness of disaster resilience strategies implemented by FICELCO shows an overall weighted mean of 3.56, verbally interpreted as "Strongly Agree/Highly Effective." Among the strategies, Emergency Response and Restoration Protocols ranked highest (3.58), followed closely by Workplace Training and Capacity Building (3.57), Infrastructure Hardening and Redundancy (3.56), Real-time Monitoring and Early Warning Systems (3.54), and Community Engagement and Awareness Programs

(3.53). These results indicate that FICELCO's personnel perceive the cooperative's strategies as highly effective in maintaining service reliability during and after disasters.

Overall, the findings reflect a robust implementation of disaster resilience measures, supported by both organizational planning and personnel capacity. This aligns with the Philippine policy environment, where Republic Act No. 11039 provides electric cooperatives with dedicated funds for rapid restoration and rehabilitation of damaged facilities (Official Gazette of the Republic of the Philippines, 2018). While national-level studies have highlighted the importance of energy-sector resilience and renewable integration (Bertheau et al., 2020; Salac et al., 2024), localized research in highly exposed areas like Catanduanes remains limited. The strong effectiveness ratings reported by FICELCO personnel underscore the value of targeted operational strategies, infrastructure investment, and continuous capacity building to mitigate the socio-economic and geographic vulnerabilities inherent in off-grid island energy systems (Chong et al., 2025).

Table 4.1
Significant Difference in the Challenges Faced by Personnel of FICELCO in Maintaining Service Reliability during and after Disaster in terms of Infrastructure Vulnerability and Damage when grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**4.10**	**.0245**	Reject Ho	Significant Difference
Sex	**t-test**	**0.00**	**1.000**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**4.43**	**.0100**	Reject Ho	Significant Difference
Length of Service at FICELCO	**F-test**	**4.25**	**.0217**	Reject Ho	Significant Difference
Department /Unit Assigned	**F-test**	**3.70**	**.0048**	Reject Ho	Significant Difference
Number of trainings attended related to disaster resilience and power restoration	**F-test**	**3.29**	**.0478**	Reject Ho	Significant Difference

The analysis shows that the challenges faced by FICELCO personnel in maintaining service reliability during and after disasters differ significantly across several profile variables. Specifically, age ($F = 4.10$, $p = .0245$), job position ($F = 4.43$, $p = .0100$), length of service ($F = 4.25$, $p = .0217$), department/unit assigned ($F = 3.70$, $p = .0048$), and the number of disaster resilience and power restoration trainings attended ($F = 3.29$, $p = .0478$) all exhibited significant differences, leading to the rejection of the null hypothesis. In contrast, sex ($t = 0.00$, $p = 1.000$) showed no significant difference, indicating that male and female personnel perceive infrastructure vulnerability and damage challenges similarly. These results suggest that experience, organizational role, departmental context, and training exposure influence how staff encounter and manage infrastructure-related challenges during disasters.

Overall, the findings highlight that operational realities at FICELCO are shaped by both human and structural factors, consistent with the literature emphasizing the vulnerability of off-grid electric cooperatives in highly exposed island settings (Bertheau et al., 2020; Salac et al., 2024). Repeated disaster impacts exacerbate infrastructure fragility and logistical constraints, while differences in role, experience, and training affect personnel's capacity to respond effectively. This underscores the importance of tailored resilience strategies and capacity-building initiatives to strengthen service reliability and long-term adaptation in geographically and climatically vulnerable regions like Catanduanes.

Table 4.2
Significant Difference in the Challenges Faced by Personnel of FICELCO in Maintaining Service Reliability during and after Disaster in terms of Communication and Coordination Issues when Respondents are Grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**0.70**	**.5647**	**Accept Ho**	**No Significant Difference**
Sex	**t-test**	**0.00**	**1.000**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**2.23**	**.1023**	**Accept Ho**	**No Significant Difference**
Length of Service at FICELCO	**F-test**	**1.17**	**.3521**	**Accept Ho**	**No Significant Difference**
Department /Unit of Assignment	**F-test**	**3.70**	**.0048**	Reject Ho	Significant Difference
Number of trainings attended related to disaster resilience and power restoration	**F-test**	**4.79**	**.0144**	Reject Ho	Significant Difference

The analysis shows that challenges in communication and coordination during and after disasters among FICELCO personnel are largely consistent across most profile variables. Age ($F = 0.70$, $p = .5647$), sex ($t = 0.00$, $p = 1.000$), job position ($F = 2.23$, $p = .1023$), and length of service ($F = 1.17$, $p = .3521$) all show no significant difference, indicating that employees perceive communication and coordination challenges similarly regardless of these characteristics. However, significant differences were observed for department/unit of assignment ($F = 3.70$, $p = .0048$) and the number of trainings attended related to disaster resilience and power restoration ($F = 4.79$, $p = .0144$), suggesting that organizational placement and prior training influence how personnel experience communication and coordination issues during emergencies.

Overall, these findings highlight that while demographic factors do not affect perceptions of communication challenges, operational context and preparedness through training play a crucial role. This aligns with Alozie et al. (2024), who emphasize that off-grid energy systems require structured procedures, continuous monitoring, and redundancy to maintain service during disasters. Similarly, Pemmasani and Abd Nasaruddin (2022) note that well-coordinated crisis management supported by IT systems strengthens disaster response, reinforcing the need for targeted training and department-specific strategies to enhance coordination and reliability in FICELCO's operations.

Table 4.3
Difference in the Challenges Faced by Personnel of FICELCO in Maintaining Service Reliability during and after Disaster in terms of Resource Limitations when Respondents are Grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**0.07**	**.9766**	**Accept Ho**	**No Significant Difference**
Sex	**t-test**	**0.00**	**1.00**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**0.44**	**.7754**	**Accept Ho**	**No Significant Difference**
Length of Service at FICELCO	**F-test**	**1.52**	**.2473**	**Accept Ho**	**No Significant Difference**
Department /Unit Assigned	**F-test**	**9.47**	**.0313**	Reject Ho	Significant Difference
Number of	**F-test**	**1.59**	**.2305**	**Accept Ho**	**No Significant Difference**

trainings attended related to disaster resilience and power restoration					

The analysis indicates that challenges related to resource limitations in maintaining service reliability during and after disasters among FICELCO personnel are generally consistent across most profile variables. Age (F = 0.07, p = .9766), sex (t = 0.00, p = 1.00), job position (F = 0.44, p = .7754), length of service (F = 1.52, p = .2473), and number of disaster resilience trainings attended (F = 1.59, p = .2305) all show no significant differences, suggesting that these characteristics do not affect employees' perceptions of resource-related challenges. However, department or unit assignment (F = 9.47, p = .0313) shows a significant difference, indicating that personnel's operational area influences how resource limitations are experienced during disaster response.

Overall, these findings underscore that resource constraints are a common challenge for off-grid energy operations, yet their impact varies by organizational context. This aligns with Shittu et al. (2018), who emphasize that effective communication is critical in managing limited resources during disasters, enabling faster coordination and recovery. Karaman et al. (2025) further highlight that secure, flexible, and deployable communication systems support emergency operations even under extreme conditions. Therefore, addressing department-specific resource limitations and improving communication infrastructure are essential to enhance FICELCO's disaster response and service reliability.

Table 4.4
Difference in the Challenges Faced by Personnel of FICELCO in Maintaining Service Reliability during and after Disaster in terms of Environmental and Geographical Challenges when Respondents are Grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**0.59**	**.6315**	**Accept Ho**	**No Significant Difference**
Sex	**t-test**	**0.00**	**1.000**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**2.93**	**.0468**	Reject Ho	Significant Difference
Length of Service at FICELCO	**F-test**	**3.92**	**.0284**	Reject Ho	Significant Difference
Department /Unit Assigned	**F-test**	**0.79**	**.6019**	**Accept Ho**	**No Significant Difference**
Number of trainings attended related to disaster resilience and power restoration	**F-test**	**0.31**	**.8192**	**Accept Ho**	**No Significant Difference**

The analysis oshows that challenges related to environmental and geographical factors in maintaining service reliability during and after disasters are influenced by certain respondent characteristics. Age (F = 0.59, p = .6315), sex (t = 0.00, p = 1.000), department/unit assigned (F = 0.79, p = .6019), and number of disaster resilience trainings attended (F = 0.31, p = .8192) show no significant differences, indicating uniform perceptions across these variables. However, job position (F = 2.93, p = .0468) and length of service at FICELCO (F = 3.92, p = .0284) reveal significant differences, suggesting that employees' roles and experience levels influence how environmental and geographical challenges are encountered during disaster response. Overall, these findings highlight that environmental and geographical conditions pose operational challenges that are perceived differently depending on staff responsibilities

and tenure. This aligns with studies emphasizing that energy resilience relies on adaptive strategies such as microgrids, distributed energy sources, and backup power systems to maintain operations during emergencies (Cabrera-Tobar et al., 2023; Bouramdane, 2024). The integration of modern technologies, including smart grids and predictive tools using artificial intelligence, further enhances planning and mitigation against natural hazards (Almihat & Munda, 2025; Nyangon, 2024). Strengthening these strategies in conjunction with role-specific training can improve FICELCO's capacity to respond effectively to environmental and geographic challenges.

Table 4.5
Significant Difference in the Challenges Faced by Personnel of FICELCO in Maintaining Service Reliability during and after Disaster in terms of Public Expectation and Communications when Respondents are Grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**1.46**	**.2618**	**Accept Ho**	**No Significant Difference**
Sex	**t-test**	**0.00**	**1.000**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**0.90**	**.4813**	**Accept Ho**	**No Significant Difference**
Length of Service at FICELCO	**F-test**	**0.62**	**.6148**	**Accept Ho**	**No Significant Difference**
Department /Unit Assigned	**F-test**	**4.94**	**.0007**	Reject Ho	Significant Difference
Number of trainings attended related to disaster resilience and power restoration	**F-test**	**3.38**	**.0443**	Reject Ho	Significant Difference

The analysis indicates that challenges related to public expectations and communications during and after disasters are generally consistent across most profile variables. Age ($F = 1.46$, $p = .2618$), sex ($t = 0.00$, $p = 1.000$), job position ($F = 0.90$, $p = .4813$), and length of service ($F = 0.62$, $p = .6148$) show no significant differences, suggesting that perceptions of public expectation and communication challenges are similar among these groups. However, significant differences were observed for department/unit assigned ($F = 4.94$, $p = .0007$) and the number of disaster resilience and power restoration trainings attended ($F = 3.38$, $p = .0443$), indicating that organizational placement and prior training influence how personnel perceive and manage communication with the public during emergencies.

Overall, these findings highlight that while demographic factors do not strongly affect perceptions of public communication challenges, operational context and preparedness through training are critical. This aligns with research emphasizing the role of energy storage and demand response systems in enhancing resilience, stabilizing supply, and accelerating recovery during emergencies (Ojo et al., 2025). Additionally, technologies such as electric vehicles can serve as mobile storage units to support resilience, although their effectiveness depends on equitable access and local conditions (Loni & Asadi, 2024). These insights reinforce the need for FICELCO to integrate strategic training and infrastructure solutions to improve communication and meet public expectations during disaster response.

Table 5.1
Difference in the Level of Effectiveness of the Disaster Resilience Strategies Implemented by FICELCO to Ensure Reliability during and after Disaster in terms of Infrastructure Hardening and Redundancy when Grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**1.50**	**.2532**	**Accept Ho**	**No Significant Difference**
Sex	**t-test**	**0.00**	**1.000**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**0.84**	**.5165**	**Accept Ho**	**No Significant Difference**
Length of Service at FICELCO	**F-test**	**1.32**	**.3023**	**Accept Ho**	**No Significant Difference**
Department /Unit Assigned	**F-test**	**8.13**	**.0492**	Reject Ho	Significant Difference
Number of trainings attended related to disaster resilience and power restoration	**F-test**	**3.03**	**.0598**	**Accept Ho**	**No Significant Difference**

The analysis shows that the level of effectiveness of Infrastructure Hardening and Redundancy as a disaster resilience strategy is largely perceived similarly across most profile variables. Age ($F = 1.50$, $p = .2532$), sex ($t = 0.00$, $p = 1.000$), job position ($F = 0.84$, $p = .5165$), length of service ($F = 1.32$, $p = .3023$), and number of disaster resilience trainings attended ($F = 3.03$, $p = .0598$) show no significant differences, indicating uniform perceptions among these groups. However, department or unit assigned ($F = 8.13$, $p = .0492$) shows a significant difference, suggesting that employees' operational context influences how they perceive the effectiveness of infrastructure hardening and redundancy measures.

Overall, these findings suggest that while demographic and experience factors do not significantly affect perceptions, organizational placement plays a key role in evaluating infrastructure resilience strategies. This aligns with existing literature noting that off-grid electric cooperatives in highly exposed areas like Catanduanes face unique operational constraints, including fragile infrastructure, logistical challenges, and financial pressures from repeated disaster impacts (Bertheau et al., 2020; Salac et al., 2024). Strengthening infrastructure through targeted hardening measures and redundancy, especially tailored to departmental operations, is therefore critical to enhancing FICELCO's capacity for reliable service during and after disasters.

Table 5.2
Difference in the Level of Effectiveness of the Disaster Resilience Strategies Implemented by FICELCO to Ensure Reliability during and after Disaster in terms of Real-time monitoring and Early Warning Systems when Grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**5.56**	**.0083**	Reject Ho	Significant Difference
Sex	**t-test**	**0.00**	**1.0000**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**1.98**	**.1368**	**Accept Ho**	**No Significant Difference**
Length of Service at FICELCO	**F-test**	**1.02**	**.4113**	**Accept Ho**	**No Significant Difference**
Department /Unit	**F-test**	**2.27**	**.0536**	**Accept Ho**	**No Significant Difference**

Assigned					
Number of trainings attended related to disaster resilience and power restoration	**F-test**	**1.69**	**.2090**	**Accept Ho**	**No Significant Difference**

The analysis indicates that the perceived effectiveness of Real-time Monitoring and Early Warning Systems as a disaster resilience strategy shows a significant difference only across age groups (F = 5.56, p = .0083), suggesting that employees of different ages perceive the utility and impact of these systems differently. No significant differences were observed for sex (t = 0.00, p = 1.000), job position (F = 1.98, p = .1368), length of service (F = 1.02, p = .4113), department/unit assigned (F = 2.27, p = .0536), or number of disaster resilience trainings attended (F = 1.69, p = .2090), indicating consistent perceptions across these variables.

Overall, these findings underscore that while most demographic and operational factors do not affect perceptions, age-related differences may influence how personnel interact with or value real-time monitoring and early warning systems. This aligns with the literature emphasizing that maintaining resilience in off-grid energy systems requires well-planned, technology-based approaches, including continuous monitoring and integrated IT-supported crisis management (Alozie et al., 2024; Pemmasani & Abd Nasaruddin, 2022). Implementing age-sensitive training and familiarization programs may further enhance the effectiveness of these systems in sustaining service reliability during and after disasters.

Table 5.3
Difference in the Level of Effectiveness of the Disaster Resilience Strategies Implemented by FICELCO to Ensure Reliability during and after Disaster in terms of Emergency Response and Restoration Protocols when Grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**1.34**	**.2959**	**Accept Ho**	**No Significant Difference**
Sex	**t-test**	**0.00**	**1.000**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**1.07**	**.3992**	**Accept Ho**	**No Significant Difference**
Length of Service at FICELCO	**F-test**	**2.37**	**.1087**	**Accept Ho**	**No Significant Difference**
Department /Unit Assigned	**F-test**	**3.69**	**.0049**	Reject Ho	Significant Difference
Number of trainings attended related to disaster resilience and power restoration	**F-test**	**2.18**	**.1300**	**Accept Ho**	**No Significant Difference**

The analysis shows that the perceived effectiveness of Emergency Response and Restoration Protocols as a disaster resilience strategy is generally consistent across most profile variables. Age (F = 1.34, p = .2959), sex (t = 0.00, p = 1.000), job position (F = 1.07, p = .3992), length of service (F = 2.37, p = .1087), and number of disaster resilience trainings attended (F = 2.18, p = .1300) show no significant differences, indicating uniform perceptions among these groups. However, department/unit assigned (F = 3.69, p = .0049) shows a significant difference, suggesting that personnel's operational area influences their perception of the effectiveness of emergency response and restoration measures. Overall, these findings

highlight that while demographic and experience factors do not significantly affect perceptions, departmental context plays a critical role in evaluating emergency response protocols. This aligns with existing literature emphasizing the importance of reliable communication during disasters, which enables faster coordination and effective restoration of electricity in isolated areas (Shittu et al., 2018; Karaman et al., 2025). Strengthening secure, flexible, and easily deployable communication systems in tandem with department-specific operational protocols can enhance FICELCO's capacity to respond efficiently and maintain service reliability during and after disasters.

Table 5.4
Difference in the Level of Effectiveness of the Disaster Resilience Strategies Implemented by FICELCO to Ensure Reliability during and after Disaster in terms of Workplace Training and Capacity Building when Grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**1.81**	**.1857**	**Accept Ho**	**No Significant Difference**
Sex	**t-test**	**0.00**	**1.000**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**1.80**	**.1676**	**Accept Ho**	**No Significant Difference**
Length of Service at FICELCO	**F-test**	**2.92**	**.0660**	**Accept Ho**	**No Significant Difference**
Department /Unit Assigned	**F-test**	**4.41**	**.0016**	Reject Ho	Significant Difference
Number of trainings attended related to disaster resilience and power restoration	**F-test**	**7.03**	**.0031**	Reject Ho	Significant Difference

The analysis indicates that the perceived effectiveness of Workplace Training and Capacity Building as a disaster resilience strategy shows significant differences for department/unit assigned ($F = 4.41$, $p = .0016$) and the number of disaster resilience trainings attended ($F = 7.03$, $p = .0031$). This suggests that personnel's operational area and prior training exposure influence their perception of the value and effectiveness of training programs. In contrast, age ($F = 1.81$, $p = .1857$), sex ($t = 0.00$, $p = 1.000$), job position ($F = 1.80$, $p = .1676$), and length of service ($F = 2.92$, $p = .0660$) show no significant differences, indicating that these factors do not affect perceptions of training effectiveness.

Overall, these findings highlight the critical role of targeted and department-specific training in strengthening disaster resilience. This aligns with research emphasizing that energy resilience depends on adaptive and technology-supported strategies, such as microgrids, distributed energy sources, and backup power systems (Cabrera-Tobar et al., 2023; Bouramdane, 2024). Moreover, modern grid technologies, smart grids, and predictive tools using artificial intelligence enhance planning, monitoring, and automated response to natural hazards (Almihat & Munda, 2025; Nyangon, 2024). Strengthening workplace training and capacity building in alignment with departmental responsibilities and prior experience can therefore improve FICELCO personnel's preparedness and operational effectiveness during disasters.

Table 5.5
Difference in the Level of Effectiveness of the Disaster Resilience Strategies Implemented by FICELCO to Ensure Reliability during and after Disaster in terms of Community Engagement when Grouped according to Profile Variables

Variables	Statistical Test	Computed Value	P-Value @ .05	Decision	Interpretation
Age	**F-test**	**1.13**	**.3654**	**Accept Ho**	**No Significant Difference**
Sex	**t-test**	**0.00**	**1.000**	**Accept Ho**	**No Significant Difference**
Job Position	**F-test**	**2.48**	**.0770**	**Accept Ho**	**No Significant Difference**
Length of Service at FICELCO	**F-test**	**4.78**	**.0146**	Reject Ho	Significant Difference
Department /Unit Assigned	**F-test**	**5.16**	**.0005**	Reject Ho	Significant Difference
Number of trainings attended related to disaster resilience and power restoration	**F-test**	**2.25**	**.1222**	**Accept Ho**	**No Significant Difference**

The analysis of Table 5.5 shows that the perceived effectiveness of Community Engagement as a disaster resilience strategy differs significantly across length of service ($F = 4.78$, $p = .0146$) and department/unit assigned ($F = 5.16$, $p = .0005$), indicating that employees' tenure and operational context influence how they view the value and impact of community-focused programs. In contrast, age ($F = 1.13$, $p = .3654$), sex ($t = 0.00$, $p = 1.000$), job position ($F = 2.48$, $p = .0770$), and the number of disaster resilience trainings attended ($F = 2.25$, $p = .1222$) show no significant differences, suggesting uniform perceptions across these groups.

Overall, these findings highlight that tailored strategies targeting departments and experienced personnel enhance the effectiveness of community engagement initiatives. This aligns with research emphasizing the role of energy storage, demand response, and flexible technologies in stabilizing power supply and accelerating recovery during disasters (Ojo et al., 2025; Loni & Asadi, 2024). Effective disaster resilience in off-grid systems relies on combining communication, technology, crisis management, and community-based approaches, adapted to the specific operational and geographic challenges faced by isolated areas, such as those served by FICELCO.

PROPOSED STRATEGIC INTERVENTION PLAN

Objectives	Activities/Strategies	Persons Involved	Time Frame	Resources Needed	Expected Outcomes
1. Strengthen infrastructure resilience against disaster impacts	**- Conduct comprehensive risk mapping of all electrical lines, posts, and substations located in hazard-prone areas** **- Retrofit vulnerable lines and reinforce poles using disaster-resilient materials (e.g., concrete poles, steel crossarms)**	**Technical Services Dept., Area Office Department, External Contractors, LGUs**	**Q3 2025 – Q1 2026**	**Infrastructure risk map, budget for materials (poles, cables, reinforcements), GIS system, coordination with LGUs**	90% reduction **in infrastructure-related service failures in high-risk areas during disasters (as measured by incident reports and downtime logs over the next 12 months)**

	- Prioritize infrastructure upgrades in flood-prone and landslide-prone zones **- Implement underground cabling in selected high-risk urban zones** **- Monitor line stability through monthly technical audits**				
2. Enhance internal and external communication and coordination protocols	**- Install two-way radio communication system with satellite fallback** **- Develop and test Emergency Communication SOPs for each department** **- Establish a centralized Disaster Command Center with digital dashboards** **- Coordinate with LGUs for early warning data sharing** **- Conduct quarterly emergency communication drills**	**Dispatch Officers, Technical Services Departement, ICT Team, Office of the General Manager, Area Offices**	**Q3 2025**	**Radios, ICT platform, training modules, LGU MOAs**	95% response rate **to disaster incidents within 30 minutes of occurrence during drills and actual emergencies**
3. Address resource limitations by optimizing logistics and readiness	**- Develop and distribute Mobile Emergency Response Toolkits (MERTs) to each area office** **- Pre-position generator sets and pole repair kits in island-barangays and remote sitios** **- Organize 24/7 rotating standby teams during typhoon season** **- Maintain a digital inventory and monitoring system of available logistics**	**Logistics Team, Admin Dept., Area Offices**	**Q4 2025 – Q1 2026**	**MERTs, vehicles, inventory system, emergency warehouse**	80% reduction **in logistics delay time during post-disaster response (from 4–6 hours down to 1–2 hours)**
4. Increase staff capacity through continuous	**- Conduct quarterly simulation drills on post-disaster power restoration**	**HR, Internal Audit, Technical Services Dept.**	**Q3 2025 – Q2 2026**	**Training materials, venue, facilitators, certification**	100% staff participation **in training activities with** at

training and capacity building	**- Organize annual Disaster Preparedness Certification Program for field staff** **- Train 100% of linemen and technicians in advanced grid repair technologies** **- Partner with NDRRMC for training in emergency response and safety**	**Area Office Department, External Trainers**		**system**	least 90% passing rate **in post-training assessment**
5. Improve stakeholder engagement and expectation management	**- Launch IEC campaign on "What to Expect During Power Interruptions" using radio, social media, and barangay assemblies** **- Set up a real-time online power outage tracker for consumer updates** **- Conduct semi-annual Power Talks in communities to explain disaster protocols** **- Train customer service reps in crisis communication**	**Consumer Services Dept., Comms Team, ICT, LGUs**	**Q4 2025 – Q2 2026**	**IEC materials, community venues, digital tracker, media partners**	50% decrease **in consumer complaints related to post-disaster restoration timelines (based on CSR logs and feedback)**

The proposed strategic intervention plan for FICELCO outlines a comprehensive approach to enhance disaster resilience and ensure reliable service during and after disasters. Key strategies include strengthening infrastructure through risk mapping, retrofitting vulnerable lines, prioritizing upgrades in hazard-prone areas, and implementing underground cabling, aiming for a 90% reduction in infrastructure-related service failures. Communication and coordination are also prioritized, with two-way radios, a centralized Disaster Command Center, emergency SOPs, and LGU coordination targeting a 95% response rate within 30 minutes of incidents. Resource limitations are addressed through Mobile Emergency Response Toolkits, pre-positioned generators, standby teams, and digital inventory systems to reduce post-disaster logistics delays by 80%.

Capacity building and stakeholder engagement form the second pillar of the plan. Staff training through simulation drills, certification programs, and advanced grid repair workshops is expected to achieve 100% participation with at least a 90% passing rate. Community engagement strategies, including IEC campaigns, real-time outage trackers, and Power Talks, aim to reduce consumer complaints by 50%. Overall, the plan integrates infrastructure reinforcement, communication, logistics, training, and community-focused strategies,

strengthening FICELCO's operational resilience and ensuring effective service restoration in disaster-prone areas.

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