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Green Microfinance and Climate Resilience: Evaluating the Role of Financial Inclusion in Building Sustainable Livelihoods in Vulnerable Economies

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Abstract: **The effect of climate change on livelihood vulnerability has increased in developing countries and hence there is need for creative financing mechanisms that create resilience and sustainable development. The study looks into the associations between Green Microfinance (GMF), Financial Inclusion (FI), Climate Adaptation Capacity (CAC), Sustainable Livelihoods (SL), Climate Resilience (CR) and Institutional Support (IS) in vulnerable economies. Based on the Sustainable Livelihood Approach and Financial Inclusion Theory, a theoretical framework was developed and tested using the Structural Equation Modeling (SEM) method. Primary data was gathered from 533 survey participants using a structured questionnaire under a stratified random sampling technique. The measurement model showed very good psychometrics properties with high factor loadings, acceptable reliability and validity and good model fitness ($\chi^2/df = 2.038$, CFI = 0.982, TLI = 0.980, RMSEA = 0.044). The exploratory factor analysis yielded six separate constructs accounting for 88.73% of the total variance. But the structural model indicated that most of the assumed associations are statistically insignificant whereas the Climate Adaptation Capacity has a negative significant impact on Sustainable Livelihoods ($\beta = -0.091$, $p < 0.05$). The above discussion implies that climate adaptation projects are likely to incur initial costs for economic activities and produce livelihood gains over time, especially in economies where there are resource constraints. In addition, the findings imply that green microfinance and institutional approaches are not sufficient enough to improve financial inclusion and resilience to climate change without making additional investments in capacity building, good governance, financial education, and livelihood diversification. The current research makes an essential contribution to the literature since it brings together green finance, financial inclusion, and resilience to climate change in one research framework and develops a measurement tool to be used in future research studies.**

Keywords: **Green Microfinance; Financial Inclusion; Climate Adaptation Capacity; Sustainable Livelihoods; Climate Resilience; Institutional Support; Sustainable Finance; Vulnerable Economies and Sustainable Development.**

I. INTRODUCTION

The problem of climate change is considered to be one of the most significant challenges of the twenty-first century and can threaten the economic stability, ecological sustainability and social well-being in developed and developing countries. The Intergovernmental Panel on Climate Change states that such problems like the increase of global temperature, more frequent natural disasters, increase of sea level and damage of ecosystems have made the situation even more difficult by causing vulnerability of livelihoods, especially low-income groups who are engaged in agricultural and fishing practices

[1]. Developing countries suffer from these threats more than other countries due to the lack of institutional capacity and financial sources needed for the effective response to the climate risks. Therefore, climate resilience becomes one of the main aims of global sustainable development strategies and needs innovative financial tools to achieve it. The importance of financial inclusion as a facilitator for climate adaptation and sustainable development has come into focus in recent years [2]. Financial services such as savings, credit, insurance, payments, and digital finance improve the ability of households to invest in productive assets, diversify income streams, recover from environmental shocks, and use climate-smart technologies. An inclusive financial system allows for investments in renewable energy, water management, sustainable agriculture, and environmentally sound business ventures thus enhancing economic and ecological sustainability [3]. Recent literature shows that financial inclusion is associated with positive impacts on poverty reduction, household resilience, entrepreneurship, and social inclusion, while at the same time building adaptive capacity to climate change risks. Microfinance institutions have been key actors in increasing access to finance by poor populations in the past. While microfinance started off with Muhammad Yunus' innovations in microcredit provision, it has since then developed into a broader concept including savings, insurance, remittances, enterprise development, financial education, and digital financial inclusion [4]. Modern microfinance acknowledges that financial services should not just alleviate poverty, but also support environmental sustainability and climate adaptation. Such developments have led to the emergence of green microfinance, whereby green goals have been incorporated into the provision of financial services through renewable energy technology, sustainable farming, climate-resilient businesses, clean cook stoves, garbage management, water conservation, and environmentally sound livelihoods [5].

Green microfinance is one such interesting area where both the concepts of sustainable finance and development come together in a way that benefits the poor and promotes environmental sustainability at the same time. While conventional microfinance is largely concerned with boosting income and consumption for households, green microfinance aims to achieve a kind of multidimensional value creation through environmental sustainability and financial empowerment at the same time [6]. Financial services provided through green microfinance help people access solar-powered irrigation, biogas plants, rainwater harvesting, organic farming, climate-smart crops, energy-efficient appliances, and other environmentally sustainable options. These help not only reduce environmental degradation but also increase efficiency and productivity. It is now more than ever that the significance of green microfinance has become clear in climatically vulnerable economies in South Asia, Sub-Saharan Africa, and Latin America [7]. People living in rural areas in these locations are likely to suffer from droughts, floods, cyclones, salinity ingress, land degradation, and falling agricultural productivity on a continuous basis. Disasters caused by climatic conditions may lead to loss of property, loss of jobs, disruption of education, and multiple dimensions of poverty. Financial exclusion becomes an additional burden because it denies individuals access to emergency loans, saving facilities, insurance, and funds for adaptation [8].

The Indian case serves as a particularly pertinent example in order to analyze these interactions. Being one of the most rapidly developing nations in the world, India is faced not only with great economic growth but also with growing vulnerability to climate change caused by the monsoon rains variability, coastal erosion, heat waves, water scarcity and the increase in the number of disasters occurring. For instance, states like Tamil Nadu and Kerala face regular occurrences of hurricanes, floods, droughts and precipitation changes affecting farming households and microenterprises. While India has made impressive progress towards financial inclusion due to programs such as Pradhan Mantri Jan Dhan Yojana, there still exists great discrepancy in accessing environmentally focused financial services, particularly for women, small-scale farmers, tribes people and informal sector workers [9]. This integrative approach finds increasing support in the global policy landscape. The UN Sustainable Development Goals stress the interdependence of poverty alleviation, gender equality, decent work, action on climate change, sustainable consumption, and partnerships in achieving sustainable development. Likewise, the Paris Agreement suggests that countries should make efforts to mobilize financial flows for strengthening their ability to adapt to climate change and build resilience [10]. As a result, green finance becomes a top priority for governments, MDBs, IFIs, and other private investors in pursuing faster transitions towards sustainable development. However, most of the current literature focuses on green bonds, sustainable banking, environmental investment, and corporate sustainability rather than green microfinance [5].

The existing literature highlights some critical theoretical and empirical shortcomings. First, most studies examine financial inclusion, climate adaptation, sustainable livelihoods, and green finance individually without focusing on the relationship between the four concepts in an integrated theoretical framework. Secondly, there is sparse evidence regarding the way green microfinance enhances the climate resilience of communities [11]. Thirdly, very few studies use sophisticated analytical tools like Structural Equation Modeling to measure the direct, indirect, and moderating effects of green

microfinance on various indicators. Fourthly, institutions ranging from government policies, regulations, extension services, digital technologies, and community institutions have not been given due attention, despite their relevance in enhancing green microfinance initiatives. To overcome these limitations, this current research presents a comprehensive conceptual framework that integrates the following aspects: green microfinance, financial inclusion, capacity for climate adaptation, sustainable livelihoods, institutional support, and climate resilience [12]. In particular, the research attempts to test if financial inclusion acts as a mediator in the relationship between green microfinance and sustainable livelihoods, if climate adaptation capacity serves as another mediator, and how institutional support influences these links. Through the integration of lessons learned from the Sustainable Livelihood Approach, the research makes its contribution to the multidimensional view of sustainable finance.

II. REVIEW OF LITERATURE

The intersection of climate change, sustainable finance, and financial inclusion has revolutionized the global development paradigm and put forward green microfinance as an exciting approach towards creating climate resilient livelihoods in vulnerable economies. With the rise in climatic uncertainties, environmental degradation, and socio-economic disparities, there is growing recognition of how inclusive financial systems can support adaptation, resilience, and sustainable development. Literature shows that whereas considerable strides have been achieved in each of green finance, financial inclusion, and climate resilience separately, their synthesis is lacking. The present review highlights contemporary research in six different themes and discusses the gaps that the current research addresses.

2.1 Green Microfinance and Sustainable Development

Traditionally, microfinance has been considered a poverty reduction tool intended for increasing access to financial services for people in the poverty bracket. The domain has experienced growth since its initiation and has expanded its focus from microcredit to include deposits, insurances, remittances, and entrepreneurial finance [2;13]. Recently, environmental sustainability emerged as a new dimension in microfinance that contributed to the emergence of the green microfinance concept, which focuses on integrating environmental considerations into the provision of financial services. Green microfinance is funding environmentally sustainable livelihood activities such as using renewable energies, practicing climate-smart agriculture, collecting rainwater, using clean technologies for cooking, managing garbage, and generating eco-friendly microbusinesses [14]. Differently from traditional financing practices aimed at generating profits, the goal of green microfinance is to improve the environment, provide social support, and enhance economic stability. Thus, environment-oriented microfinance organizations reach better social outreach and good financial sustainability at the same time. Organizations that practice environmental risk control and green lending tend to have better performance than traditional microfinance institutions. Researchers stress the need for the climate microfinance sector to change from simply funding living realities to financing adaptation to climate change [15].

2.2 Financial Inclusion as a Driver of Climate Resilience

Financial inclusion has emerged as the focal point of sustainable development since it provides opportunities for people and families to use affordable financial services that stabilize their income, expand investment opportunities, and enhance their risk management skills [16]. Availability of banking services, savings accounts, insurance, electronic payments, and low-cost credits minimizes the possibility of income shocks and boosts economic sustainability in the long run. Financial inclusion facilitates households' workflow by making savings possible, helping them acquire productive assets, gaining access to emergency credits, and speeding up the process of recovery from the effects of disasters [17]. Digital financial services make this process even more effective. The scope of financial inclusion extends to areas such as social inclusion, gender equality, entrepreneurship, and poverty alleviation, tightening the correlation between life circumstance and financial access. Households possessing financial means are able to spend money on education, medical services, agricultural improvements, and sustainable diversification [3;18]. Traditional models of financial inclusion are ineffective in the provision of services accommodating climate fairness. The service sector should rethink its products offering and deal with climate challenges using climate-friendly finance solutions. That is why the concept of green financial inclusion can be regarded as a further development of traditional financial inclusion in the field of ecological wants [6;14].

2.3 Green Finance and Climate Adaptation

Green finance is the term used for financial products that provide funds for environmentally friendly activities. Some examples of green finance concepts are green bonds, sustainable banking, environmental investment funds, carbon markets, climate finance, and renewable sources financing. The creation of green financial products will help to reduce carbon

emissions, stimulate development of renewable energy sources, build sustainable infrastructure, and make innovations in environmental technology [19]. However, a significant portion of research covers policies of macroeconomic, institutional investors, corporate sustainability, and commercial banking systems and neglects household level financial inclusion. Environmental sustainability topics must be discussed in the context of financial inclusion. Scientists emphasize that unless vulnerable groups of population have the possibility to afford climate-friendly financial services, sustainable finance will not be able to fulfill the goal of inclusive development [20].

2.4 Sustainable Livelihoods and Climate Adaptation Capacity

The Sustainable Livelihood Framework is regarded as one of the leading theoretical frameworks for understanding poverty alleviation and resilience. It establishes that livelihood consists of combinations of human, financial, natural, physical, and social capital that shape household well-being. Resilience to climate change does not only depend on financial resources but the ability to adapt [21]. Households that are more encouraged to adapt will be more successful in finding new ways of earning a living, adopting climate-smart methods of farming, implementing renewable technologies, and recovering from the impact of nature disasters. This means that adaptation to climate change has become an important intermediary factor connecting financial resources with sustainable livelihoods [22]. Financial services give people the opportunity to grow drought-resistant crops and to invest in efficient irrigation systems, renewable energy, construction of climate-resilient houses, etc. In academic literature adaptation capacity is recognized as multidimensional concept that involves knowledge transfer, use of technology, institutional support, participation in communities, and financial preparedness [11; 17].

2.5 Institutional Support and Climate Governance

The significance of institutional quality has been rising in sustainability studies since the effective governance has a strong impact on climate adaptation effectiveness. Financial regulators, governments, development organizations, local bodies, and other institutions determine the effectiveness of green financing through their policies, regulations, provision of technical support, provision of infrastructure, and use of incentives [23]. Organizations and individuals respond to formal rules, normative pressures, and social legitimacy. Green microfinance institutions are more likely to perform better given the supportive institutional environment because borrowers obtain value-addition services such as education on environmental issues, technical training, infrastructure, and access to markets [5]. Climate resilience is not achieved through finances alone, but it requires institutional coordination in order to achieve information flow, inventions, and climate governance [24].

2.6 Climate Resilience and Vulnerable Economies

The phrase ‘climate resilience’ means the ability of individuals, families, communities or organizations to expect and solve the climatic shocks, to recover from them, to cope with them and get the necessary functions of development [25]. People in poverty, women, indigenous population, small farmers and informal workers are considered most vulnerable to climate conditions due to lack of funds, availability of weak institutions and limited forms of adaptation [26]. Help for people in poverty consists of a few aspects that deal with resilience. Recently resilience has begun being understood and regarded as a concept of four things: economic resilience, social resilience, economical resilience, institutional resilience and adaptive resilience [27]. It means that financial solutions that are being chosen should take into account these facts. Those people who have various sources of income and have good access to financial institutions and systems show less vulnerability to natural disasters [28].

TABLE I: HYPOTHESIS DEVELOPMENT MATRIX

Hypothesis	Independent Variable	Dependent Variable	Theoretical Justification	Empirical Evidence (Recent Studies)
H1	Green Microfinance	Financial Inclusion	Green microfinance enhances access to affordable credit, green savings, insurance, renewable energy financing, and financial literacy, thereby improving participation in formal financial systems among vulnerable households.	Recent studies demonstrate that green financial products significantly improve financial accessibility and banking participation in developing economies [6; 13; 18; 24].

H2	Financial Inclusion	Climate Adaptation Capacity	Access to formal financial services enables households to invest in climate-smart agriculture, renewable energy, disaster preparedness, and adaptive technologies, thereby strengthening adaptive capacity.	Financial inclusion improves adaptive investments, disaster recovery, and resilience among climate-vulnerable communities [2; 17; 21; 23; 25].
H3	Climate Adaptation Capacity	Sustainable Livelihoods	Households possessing stronger adaptive capacity are better able to diversify livelihoods, improve productivity, reduce environmental risks, and maintain long-term income stability.	Climate adaptation strategies significantly improve livelihood diversification, agricultural productivity, and food security [9; 14].
H4	Sustainable Livelihoods	Climate Resilience	Sustainable livelihoods improve households' ability to absorb, recover from, and adapt to climate-induced shocks through diversified income, social capital, and economic security.	Sustainable livelihood strategies significantly enhance resilience to floods, droughts, and climate variability [1; 6; 15; 21].
H5	Institutional Support (Moderator)	Green Microfinance → Financial Inclusion	Supportive government policies, financial regulations, digital infrastructure, and financial literacy programmes strengthen the effectiveness of green microfinance in expanding financial inclusion.	Institutional quality significantly enhances financial inclusion and sustainable finance outcomes [3; 12; 21].
H6	Institutional Support (Moderator)	Financial Inclusion → Climate Adaptation Capacity	Institutional support facilitates extension services, climate information systems, and technical assistance that enable households to convert financial access into effective adaptation strategies.	Government interventions strengthen climate adaptation through capacity building and institutional coordination [15; 18; 24].
H7	Institutional Support (Moderator)	Climate Adaptation Capacity → Sustainable Livelihoods	Institutional support enhances market access, agricultural extension, environmental education, and technological diffusion, thereby strengthening the livelihood benefits of adaptation.	Institutional capacity significantly improves livelihood sustainability and adaptation effectiveness [13; 17; 21; 26].
H8	Institutional Support (Moderator)	Sustainable Livelihoods → Climate Resilience	Effective institutions provide disaster risk management, social protection, environmental governance, and financial safety nets that reinforce the resilience generated through sustainable livelihoods.	Institutional resilience enhances long-term adaptive capacity and community resilience [6; 14; 19; 22; 27].

III. RESEARCH METHODOLOGY

This research uses a quantitative approach to comprehend the interconnections among Green Microfinance (GMF), Financial Inclusion (FI), Climate Adaptation Capacity (CAC), Sustainable Livelihoods (SL), Climate Resilience (CR), and the role of Institutional Support (IS) in this. The cross-sectional research design has been employed, according to which data has been gathered at one point of time from participants. This design is prevalent in studies related to financial inclusion, sustainable finance, and climate resilience, and is efficient in gathering people's current beliefs, actions, and adaptive capacity. The field study is specifically conducted in climate vulnerable districts of Tamil Nadu (Nagapattinam, Cuddalore, Ramanathapuram, Thoothukudi and Thanjavur) and Kerala (Alappuzha, Kottayam, Ernakulam, Pathanamthitta and Wayanad) in India as these areas face numerous climate-related threats such as cyclones, floods, droughts, coastal erosion, irregular monsoon, and salinity intrusion. Thus, the selected regions are effective for the analysis of green microfinance's

sustainability as the microfinance outreach is huge, along with the fact that green livelihood programs are followed in these districts. The specified target population would include clients of Green Microfinance Institutions (MFIs), Self-Help Groups (SHGs), Joint Liability Groups (JLGs), Farmer Producer Organizations (FPOs), women entrepreneurs, small farmers, and rural micro-enterprises benefiting from formal or semi-formal financing services. The sample was selected using multi-stage stratified random sampling. Two climate-prone states, Tamil Nadu and Kerala, are chosen on purpose because of the repeated occurrence of climate events and high coverage of microfinance institutions (stage 1). Five districts from the two states are selected according to the climate vulnerability index and the presence of microfinance institutions (stage 2). Various microfinance institutions, Self-Help Groups, cooperatives, and NGOs involved in different green finance programs are identified (stage 3) and selected in the process of choosing (stage 4). Selection of eligible clients is done using simple random sampling from the lists of their members (stage 5). The multistage approach helps in minimizing sampling bias while proving representation of wide range of socio-economic groups in different climate zones.

IV. RESULTS

The demographic characteristics of the 533 respondents analyzed in the study are shown in Table 2. Female respondents formed the majority of the sample population (78.2%) compared to male respondents (21.8%) demonstrating a better involvement of women in green microfinance and livelihood activities. As for age structure, the highest share of respondents were in the age range of 45-55 years (34.5%), 35-44 years (29.8%) and 25-34 years (25.0%) demonstrating involvement of economically active people with significant experience in livelihoods.

TABLE II. DEMOGRAPHIC PROFILE OF THE SAMPLE RESPONDENTS

Variable	Category	Frequency (n)	Percentage (%)	Mean	Standard Deviation
Gender	Male	116	21.8	**1.78**	**0.413**
	Female	417	78.2		
	Total	**533**	**100.0**		
Age	Below 25 Years	57	10.7	**2.88**	**1.005**
	25–34 Years	133	25.0		
	35–44 Years	159	29.8		
	45–55 Years	184	34.5		
	Total	**533**	**100.0**		
Educational Level	School Level	102	19.1	**3.08**	**1.465**
	Diploma	117	22.0		
	Undergraduate	78	14.6		
	Postgraduate	108	20.3		
	Others	128	24.0		
	Total	**533**	**100.0**		
Occupation	Self-employed	150	28.1	**2.25**	**0.997**
	Salaried	162	30.4		
	Agriculture	157	29.5		
	Others	64	12.0		
	Total	**533**	**100.0**		
Monthly Income (₹)	Below 10,000	61	11.4	**2.59**	**0.881**
	10,001–25,000	175	32.8		
	25,001–50,000	216	40.5		
	Above 50,000	81	15.2		
	Total	**533**	**100.0**		
Location	Rural	140	26.3	**2.13**	**0.800**
	Semi-Urban	184	34.5		
	Urban	209	39.2		
	Total	**533**	**100.0**		

As for the level of education attained by respondents, there were differences in education levels. The greatest percentage was represented by others (24.0%), Diploma holders (22.0%), Postgraduates (20.3%), School-level education (19.1%), and Undergraduates (14.6%). These results demonstrate differences in human capital and financial capability of participants. Occupation data reveal a diversified occupation structure including a high level of participation of salaried employees

(30.4%), agriculture (29.5%), self-employed (28.1%), and other occupations (12.0%). Such diversification is quite relevant for studying impact of green microfinance on various sectors of economy. In terms of monthly household income, 40.5% of participants earned ₹25,001 to ₹50,000, with another 32.8% having ₹10,001 to ₹25,000, whereas only 11.4% had their earnings lower than ₹10,000. Thus, one can conclude that majority of the respondents were from low-income or middle-income households, which are usually recipients of inclusive financial services and climate adaptation measures. Regarding residential location, urban dwellers constituted the greatest share (39.2%), followed by semi-urban (34.5%) and rural residents (26.3%). Such a distribution of the sample geographically provides more representative characteristics by including respondents living in different socio-economic and environmental conditions. Thus, based on the information obtained via descriptive analysis of demographic data, the level of variability is moderate, with mean values ranging from 1.78 to 3.08 and standard deviations from 0.413 to 1.465, which shows that there is an adequate heterogeneity of the sample. Overall, the demographic characteristics of the sample show that the study represents a cross-section of various individuals with regard to education, occupation, income, and residential area, making a proper basis for the investigation of relationships among green microfinance, financial inclusion, climate adaptation capacity, sustainable livelihoods, institutional support, and climate resilience.

Fig. 1 Demographic Profile of the Respondents

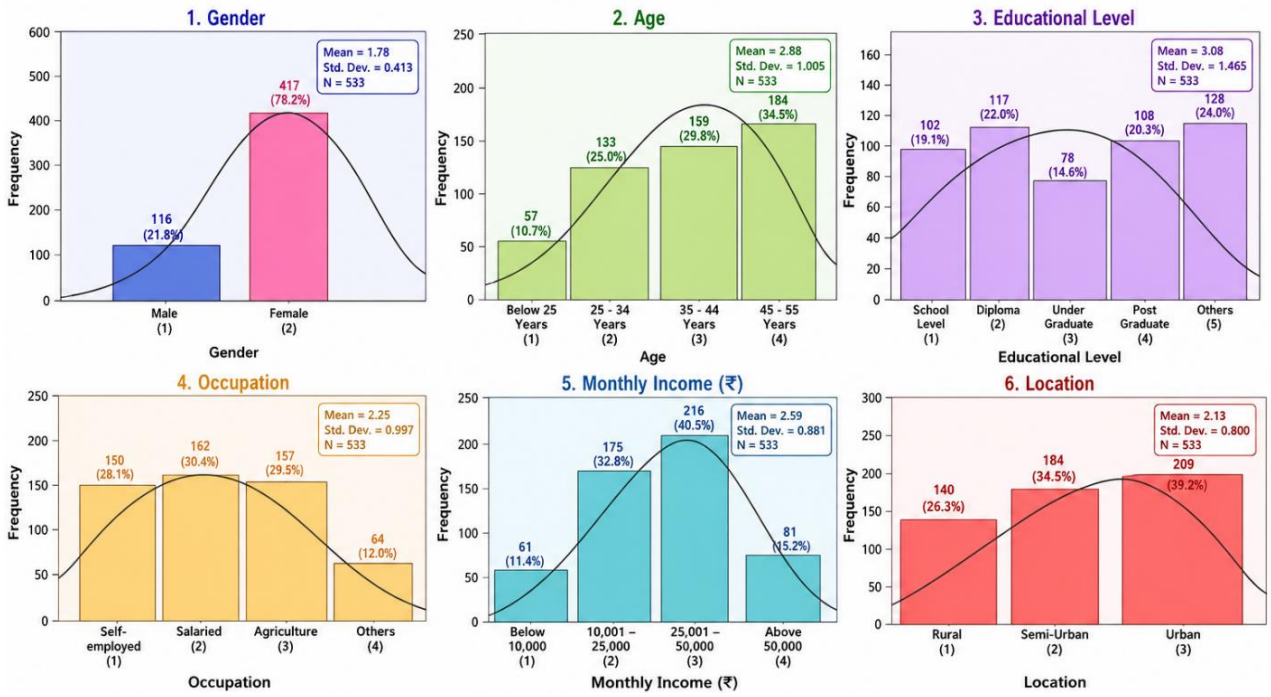


TABLE III. KMO AND BARTLETT'S TEST

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.864**
Bartlett's Test of Sphericity	Approx. Chi-Square	15347.196
	df	300
	Sig.	**.000**

Sampling adequacy for factor analysis was checked using the Kaiser-Meyer-Olkin (KMO) criterion and the Bartlett test of sphericity as indicated in Table 3. It can be noted from Table 3 that the KMO was 0.864, surpassing the cutoff value of 0.70 recommended by Hair et al. (2022), and hence reflecting meritorious sampling adequacy, suggesting that the sampling is good for conducting exploratory factor analysis. Moreover, the Bartlett test of sphericity turned out to be significant (Approx. $\chi^2 = 15{,}347.196$, df = 300, $p < 0.001$). This suggests that the correlation matrix is not an identity matrix and that there are enough correlations among the observed variables. Table 4 represents the results for PCA with varimax rotation and Kaiser normalization. In total, six factors were successfully extracted during the analysis, each one representing one of six theoretical constructs that are proposed in the conceptual model: Green Microfinance, Climate Resilience, Financial Inclusion, Climate Adaptation Capacity, Sustainable Livelihoods, and Institutional Support.

TABLE IV. ROTATED COMPONENT MATRIX

	Component					
	1	2	3	4	5	6
GMF1	.928					
GMF2	.938					
GMF3	.941					
GMF4	.939					
GMF5	.945					
FI1			.946			
FI2			.941			
FI3			.944			
FI4			.943			
CAC1				.949		
CAC2				.935		
CAC3				.941		
CAC4				.933		
SL1					.941	
SL2					.939	
SL3					.913	
SL4					.943	
IS1						.920
IS2						.932
IS3						.931
IS4						.934
CR1		.940				
CR2		.949				
CR3		.945				
CR4		.950				
Eigen values	4.924	3.956	3.615	3.390	3.275	3.022
% of Variance	19.697	15.824	14.460	13.558	13.100	12.088
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a. Rotation converged in 5 iterations.						

The rotation was successfully converged in five iterations. Factor loadings for all measurement items were very high, ranging from 0.913 to 0.950, which is much higher than the accepted minimum of 0.70 (Hair et al., 2022). In particular, items measuring GMF had very high loadings on Component 1 (0.928 – 0.945), items for CR loaded strongly on Component 2 (0.940 – 0.950), items for FI on Component 3 (0.941 – 0.946), CAC on Component 4 (0.933 – 0.949), SL on Component 5 (0.913 – 0.943), and IS on Component 6 (0.920 – 0.934). All the six components showed eigenvalues greater than one, which are in the range of 3.022 to 4.924, and they meet the criteria of Kaiser for retaining a factor. All the extracted factors together explained 88.73% of the total variance, where the first factor has explained 19.70% variance, while the second, third, fourth, fifth, and sixth factors have 15.82%, 14.46%, 13.56%, 13.10%, and 12.09% variances, respectively. It is an extraordinarily high cumulative variance, which suggests that extracted constructs successfully explain the dimensions of the data.

TABLE V. STANDARDIZED REGRESSION WEIGHTS

Measured Variables		Latent Variables	Estimate	S.E.	C.R.	P
GMF	<---	IS	-.046	.045	-1.008	.314
FI	<---	GMF	-.029	.050	-.654	.513
FI	<---	IS	.041	.050	.892	.372
CAC	<---	FI	.064	.041	1.413	.158
CAC	<---	IS	-.036	.046	-.788	.431
SL	<---	CAC	-.091	.044	-2.026	.043
SL	<---	IS	.039	.044	.851	.395
CR	<---	SL	.054	.051	1.201	.230
GMF2	<---	GMF	.927	.027	37.411	***
GMF3	<---	GMF	.929	.027	37.662	***
GMF4	<---	GMF	.921	.026	36.747	***
FI1	<---	FI	.928			
FI2	<---	FI	.921	.025	38.069	***
FI3	<---	FI	.927	.025	38.800	***
FI4	<---	FI	.925	.025	38.649	***
IS4	<---	IS	.912			
IS3	<---	IS	.907	.030	33.801	***
IS2	<---	IS	.909	.030	33.969	***
IS1	<---	IS	.896	.032	32.686	***
SL1	<---	SL	.939			
SL2	<---	SL	.919	.025	39.160	***
SL3	<---	SL	.875	.028	33.510	***
SL4	<---	SL	.938	.025	41.952	***
CAC1	<---	CAC	.943			
CAC2	<---	CAC	.907	.025	37.815	***
CAC3	<---	CAC	.923	.025	40.081	***
CAC4	<---	CAC	.911	.025	38.293	***
CR4	<---	CR	.937			
CR3	<---	CR	.928	.023	40.522	***
CR2	<---	CR	.935	.023	41.615	***
CR1	<---	CR	.917	.024	38.885	***
GMF1	<---	GMF	.914			
GMF5	<---	GMF	.942	.026	39.406	***

The regression weights for the structural equation model have been shown in Table 5. It has been found that in the structural model, most of the hypothesized relationships were not statistically significant. Green Microfinance did not have any statistically significant influence on Financial Inclusion ($\beta = -0.029$, $p = 0.513$). Additionally, Financial Inclusion did not have any statistically significant influence on Climate Adaptation Capacity ($\beta = 0.064$, $p = 0.158$). Likewise, Sustainable Livelihood had no statistically significant influence on Climate Resilience ($\beta = 0.054$, $p = 0.230$). Of all the hypothesized relationships, only the relationship between Climate Adaptation Capacity and Sustainable Livelihood was statistically significant ($\beta = -0.091$, $p = 0.043$). However, this relationship is negative, implying that increased climate adaptation capacity was associated with reduced sustainable livelihoods within the current sample population. This result contradicts the theoretical expectation and calls for further research to determine the reason behind this relationship. The variable Institutional Support failed to show any significant influence on Green Microfinance ($\beta = -0.046$, $p = 0.314$), Financial Inclusion ($\beta = 0.041$, $p = 0.372$), Climate Adaptation Capacity ($\beta = -0.036$, $p = 0.431$), and Sustainable Livelihood ($\beta = 0.039$, $p = 0.395$). Thus, the hypothesis concerning the moderating effect of Institutional Support could not be confirmed.

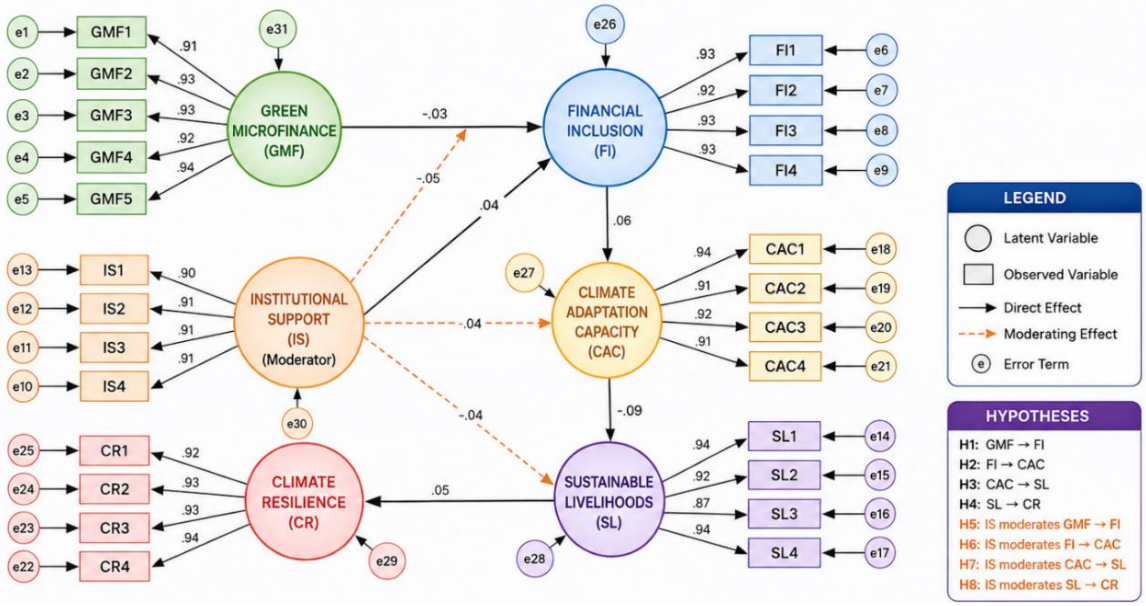
On the other hand, the measurement model showed perfect psychometric qualities. The loadings of all indicators were within the range of 0.875–0.943 and were statistically significant ($p < 0.001$), which is much higher than the recommended criterion level of 0.70. It confirms high reliability of indicators and convergent validity of all latent variables.

TABLE VI. ASSESSMENT OF STRUCTURAL MODEL FIT

Fit Index	Recommended Threshold	Obtained Value	Interpretation
χ^2/df (CMIN/DF)	< 3.00	2.038	Excellent Fit
RMR	< 0.05	0.021	Excellent Fit
GFI	≥ 0.90	0.928	Excellent Fit
AGFI	≥ 0.90	0.912	Excellent Fit
PGFI	> 0.50	0.762	Good Parsimony
NFI	≥ 0.90	0.965	Excellent Fit
RFI	≥ 0.90	0.961	Excellent Fit
IFI	≥ 0.90	0.982	Excellent Fit
TLI	≥ 0.90	0.980	Excellent Fit
CFI	≥ 0.95	0.982	Excellent Fit
PNFI	> 0.50	0.859	Good Parsimony
PCFI	> 0.50	0.874	Good Parsimony
RMSEA	< 0.06 (Good); <0.08 (Acceptable)	0.044	Excellent Fit
PCLOSE	> 0.05	0.965	Close Fit Confirmed

The Table 6 provides goodness-of-fit statistics of the suggested structural equation model. It is obvious from the table that the proposed model has an excellent fit to the observed data. Despite the significant value of chi-square statistic, which is quite typical for SEM models in large samples, the normed chi-square (χ^2/df = 2.038) was lower than the acceptable threshold of 3.0, which shows that the model had satisfactory parsimony. The absolute indices, such as RMR (0.021), GFI (0.928), and AGFI (0.912) were higher than the acceptable criteria and show good reproduction of the covariance matrix observed. Besides, the incremental fit indices demonstrated the excellent fit of the model, as NFI (0.965), RFI (0.961), IFI (0.982), TLI (0.980), and CFI (0.982) were higher than the recommended index of 0.90, whereas the latter exceeded the critical value of 0.95. The RMSEA (0.044) and PCLOSE (0.965) indicate excellent close-fitting of the model with minimal approximation error. In addition, the parsimony-adjusted indices (PGFI = 0.762, PNFI = 0.859, and PCFI = 0.874) show that the suggested model has the proper trade-off between complexity and explanatory capacity.

Fig. 2 Structural Equation Modeling



V. DISCUSSION

The interrelationships among the observed variables in vulnerable economies were studied using covariance-based structural equation modelling in this study. Against hypothesis H1, it was found that Green Microfinance did not have a statistically significant impact on Financial Inclusion ($\beta = -0.029$, $p = 0.513$). This is contradictory to prior researches which state that the environmentally driven microfinance leads to financial inclusion, savings behavior, and credit inclusion in vulnerable economies. This could be explained by the fact that having access to green microfinance products does not always mean that financial inclusion takes place. As green finance products in many developing economies are relatively new, most of the time, these are limited only to providing loan services and not the entire financial ecosystem including insurance, online banking, savings, and financial education. In such a situation, borrowers get climate-friendly loans but do not experience any change in their financial inclusion level. The finding is also consistent with the structure of vulnerable economies in which there are different factors apart from credit that affect financial exclusion, such as digital infrastructure, bank availability, financial literacy, institutional trust, and regulation.

The effect of Financial Inclusion on Climate Adaptation Capacity was positive but not significant ($\beta = 0.064$, $p = 0.158$), leading to the rejection of H2. Previous empirical literature has shown that with access to financial services, households can invest in adaptive agricultural technologies, diversify sources of income, buy climate insurance, and embrace adaptive livelihood approaches. However, the insignificant relationship implies that financial inclusion, without technical know-how, extension services, market linkage, and climate information system support, may not be sufficient for improving adaptive capacity. It implies that climate adaptation is a multi-dimensional phenomenon which needs to be addressed through various policy initiatives apart from financial inclusion. The beneficiaries may have bank accounts or loans but may lack institutional support to utilize their financial resources for climate adaptation measures. In terms of the structural relationships, only Climate Adaptation Capacity impacted Sustainable Livelihoods negatively ($\beta = -0.091$, $p = 0.043$). This result contradicts the predictions of the Sustainable Livelihoods Framework and resilience approach, which suggest that higher adaptive capacities increase the likelihood of more secure livelihoods. There are multiple context-specific reasons why such an outcome can occur. First, adaptation efforts usually require large investments into technologies, irrigation infrastructure, climate smart agriculture, and other livelihood changes. Thus, the transitional period of increased expenses might cause the perception of lower livelihood sustainability by the households. Second, people who experience greater climatic threats invest more resources in adaptation efforts. Hence, it creates a temporary negative correlation. Finally, it should be noted that the cross-sectional nature of the study means that adaptation and its effects on livelihoods are estimated at one point in time instead of the whole adaptation period. This might lead to the situation when adaptation costs are easier to observe than its economic benefits. It does not mean that the resilience theory is proven wrong but shows that there might be some transitional economic costs related to adaptation efforts.

The positive association between Sustainable Livelihoods and Climate Resilience is not statistically significant ($\beta = 0.054$, $p = 0.230$), which results in the null hypothesis rejection (H4). Literature indicates that the presence of diversified sustainable livelihoods contributes to resilience through the increase in household assets, decreased vulnerability, and enhanced ability to recover from climate disasters. In the current research, the lack of significance indicates that livelihoods' sustainability does not automatically imply that resilience is achieved in vulnerable economies. There could be other factors that contribute to climate resilience, like good infrastructure, efficient governance, disaster management, social protection programs, and community linkages. The study went further to propose that Institutional Support would moderate the proposed relationships. None of the paths estimated through Institutional Support was statistically significant. This indicates that the current institutional environment does not produce enough influence to promote financial inclusion, climate adaptation, or sustainable livelihoods. Several issues could have led to this outcome. First, institutions may lack coordination and duplication of activities due to scattered programs in various agencies. Second, there is likely a wide variation in government support across regions, which reduces the statistical impact of this variable. Third, people may view the programs run by institutions as not accessible, continuous, or effective. This shows the need for improved governance quality and institutional capacity rather than expansion of programs. It is crucial to note that Institutional Support has been estimated directly in the current model without taking into account any interactions. In other words, the current results should not be interpreted as evidence of interaction effects but evidence of the direct influence of Institutional Support on the outcomes. Future studies should estimate latent interaction effects to test whether the proposed constructs moderate the relationships between the key variables.

VI. IMPLICATION

The findings present various implications for policy makers, microfinance institutions, development organizations, and practitioners. First, green microfinance programs should not be limited to the provision of credit but should integrate financial inclusion programs which include saving options, insurance, digital financial service provision, and financial literacy programs. Such an integration would enhance the developmental outcome of green finance programs. Secondly, financial inclusion programs should be complemented by climate adaptation measures which involve training, agricultural extension services, climate information system, and market linkage facilities. Financial inclusion programs alone will be unable to deliver the necessary adaptation outcomes without climate adaptation knowledge. Thirdly, given the strong negative correlation between adaptation ability and sustainable livelihoods, the government is advised to consider measures such as adaptation subsidy, concessional loans, temporary income support, and climate risk insurance to overcome the initial cost barriers to sustainable livelihood adoption. Fourthly, more coordinated institutional action is required to implement the programs. This can be achieved through improved collaboration among governments, microfinance institutions, NGOs, agricultural extension agencies, and local communities. Moreover, the high quality of the measures found in this study shows that the scale developed is reliable enough to be used as a tool to assess green microfinance, financial inclusion, climate adaptation, sustainable livelihoods, institutional backing, and climate resilience. This scale can be utilized by researchers and policy makers for the assessment of programme efficiency and climate and financial inclusion policies.

VII. CONCLUSION

The proposed measurement framework appears to be robust and valid. Nevertheless, when analyzing the structural model, it became clear that most of the hypothesized relationships did not have statistical significance. However, the relationship between Climate Adaptation Capacity and Sustainable Livelihoods had statistical significance, but it was negative. It means that in the case of the studied economies, access to green financial services and institutional support might not be enough for the improvement of financial inclusion, adaptive capacity, and climate resilience. Thus, the study results prove that climate resilient development is a complex process that requires integration of financial mechanisms with institution building, climate knowledge sharing, livelihood diversification, and good governance. Some of the major contributions that this research provides include a sound empirical framework which considers green microfinance, financial inclusion, sustainable livelihoods, and climate resilience in one SEM model. Another contribution of this research is the provision of a multidimensional measurement instrument that will help other researchers in their research into sustainable finance and climate adaptation in the context of developing economies. Finally, some of the research findings will help policy makers understand that climate resilience will not be possible with only financial measures. In spite of the contributions made by this study, there are a number of limitations associated with it. The first one is that the cross-sectional nature of the research design used hampers the possibility of establishing causality or the long-term effects of the practice under investigation. The second limitation is associated with the collection of survey data, which is always subject to common method bias and the perceptions of respondents. The third limitation of this study lies in its empirical examination being confined to a specific geographical setting. In addition, even though Institutional Support has been introduced in the literature as a potential moderator variable, in the present study we have only tested direct structural links; hence, further studies should apply latent interaction modeling and multi-group SEM. Future studies would need to apply longitudinal research designs, incorporate objective measures of both environment and finance, conduct multi-country/region studies, and investigate mediating/moderating variables such as digital financial literacy, climate governance, social capital, policy effectiveness etc., to better understand the mechanisms through which green financial systems could support sustainable livelihoods and climate resilience in vulnerable economies.

REFERENCES

[1] Cicchiello, A. F., Kazemikhasragh, A., Monferrá, S., & Girón, A. (2021). Financial inclusion and development in the least developed countries in Asia and Africa. *Journal of Innovation and Entrepreneurship*, *10*(1), 49. https://doi.org/10.1186/s13731-021-00190-4

[2] Abdulkarim, F. M., & Ali, H. S. (2019). Financial inclusions, financial stability, and income inequality in OIC countries: a GMM and quantile regression application. *Journal of Islamic Monetary Economics and Finance*, *5*(2), 419–438.

[3] Abubakar, A. M., Daneji, B. A., Muhammed, A. I., & Chekene, I. A. B. (2020). Driving faster financial inclusion in developing nations. *Technology Audit and Production Reserves*. https://doi.org/10.15587/2706-5448.2020.201120

[4] Agyemang-Badu, A. A., Agyei, K., & Kwaku Duah, E. (2018). Financial inclusion, poverty and income inequality: Evidence from Africa. *Spiritan International Journal of Poverty Studies*, *2*(2), 1–19.

[5] Dienillah, A. A., Anggraeni, L., & Sahara, S. (2018). Impact of financial inclusion on financial stability based on income group countries. *Buletin Ekonomi Moneter Dan Perbankan*, *20*(4), 429–442. https://doi.org/10.21098/bemp.v20i4.859

[6] Koomson, I., Villano, R. A., & Hadley, D. (2020). Effect of financial inclusion on poverty and vulnerability to poverty, evidence using a multidimensional measure of financial inclusion. *Social Indicators Research*. https://doi.org/10.1007/s11205-019-02263-0

[7] Daud, S. N. M. (2023). Financial inclusion, economic growth and the role of digital technology. *Finance Research Letters*, *53*, 103602. https://doi.org/10.1016/j.frl.2022.103602

[8] Dhahri, S., Omri, A., & Mirza, N. (2024). Information technology and financial development for achieving sustainable development goals. *Research in International Business and Finance*, *67*, 102156. https://doi.org/10.1016/j.ribaf.2023.102156

[9] Omar, M. A., & Inaba, K. (2020). Does financial inclusion reduce poverty and income inequality in developing countries? A panel data analysis. *Journal of Economic Structures*, *9*(1), 1–25.

[10] Park, C. Y., & Mercado, R. (2015). Financial inclusion, poverty, and income inequality in developing Asia. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2558936

[11] Alam, E. (2018). Climate impacts and adaptation strategies of the Bangladeshi coastal communities. *Am J Environ Sci*, *14*(4), 195-202. https://doi.org/10.3844/ajessp.2018.195.202

[12] Ambrosio, N., Kim, Y. H., Swann, S., & Wang, Z. (2020). Addressing climate risk in financial decision making. In *Optimizing community infrastructure* (pp. 123-142). Butterworth-Heinemann. https://doi.org/10.1016/B978-0-12-816240-8.00007-0

[13] Huang, Y., & Zhang, Y. (2020). Financial inclusion and urban–rural income inequality: Long-run and short-run relationships. *Emerging Markets Finance and Trade*, *56*(2), 457-471. https://doi.org/10.1080/1540496X.2018.1562896

[14] Nanduri, S., Madhuchandrika, N., & Kumar, D. (2025). The Role of Sustainable Finance in Climate Resilience: Current Approaches and Knowledge Gaps. *Applied Research for Growth, Innovation and Sustainable Impact*, 427-435.

[15] Ali, E. (2026). Financial inclusion and climate change resilience in sub-Saharan Africa: a micro-level gender and households' location-based analysis. *Climatic Change*, *179*(2), 29. https://doi.org/10.1007/s10584-026-04125-4

[16] Choudhary, D. (2025). Bridging Financial Inclusion and Sustainability through Climate Fintech: Exploring the Role of Digital Microfinance Platforms in Supporting Renewable Energy Adoption and Green Development in India. *Available at SSRN 5414416*. https://dx.doi.org/10.2139/ssrn.5414416

[17] Shukla, A., Sharma, B., Shridhar, C., Gautam, S., & Naz, A. (2025). From Microfinance to Impact Finance: A Study on the Role of Financial Inclusion in Sustainable Rural Development in India. *Journal of International Commercial Law and Technology*, *6*, 1473-1483.

[18] Mahato, J., & Jha, M. K. (2023). Does financial inclusion promote sustainable livelihood development? Mediating effect of microentrepreneurship. *Journal of Financial Economic Policy*, *15*(4-5), 485-499. https://doi.org/10.1108/JFEP-05-2023-0134

[19] Gatto, A. (2023). Can renewable energy microfinance promote financial inclusion and empower the vulnerable?. *International Journal of Environment and Sustainable Development*, *22*(3), 368-373. https://doi.org/10.1504/IJESD.2023.132092

[20] Niaz, M. U. (2022). Socio-Economic development and sustainable development goals: a roadmap from vulnerability to sustainability through financial inclusion. *Economic research-Ekonomska istrazivanja*, *35*(1), 3243-3275. https://doi.org/10.1080/1331677X.2021.1989319

[21] Mhlanga, D. (2022). The role of financial inclusion and FinTech in addressing climate-related challenges in the industry 4.0: Lessons for sustainable development goals. *Frontiers in Climate*, *4*, 949178. https://doi.org/10.3389/fclim.2022.949178

[22] Fernandez-Vallado, M. (2025). Towards a policy framework for microfinance: innovative financial solutions for sustainable development. In *Microfinance, financial innovation, and sustainable entrepreneurship in economics* (pp. 139-182). IGI Global Scientific Publishing.

[23] Narayan, M., Kumar, N., Parida, V. K., & Kumari, P. (2025). Sustainable finance in emerging markets: Adaptive governance and environmental, social, and governance innovation for equitable climate resilience. *Development and Sustainability in Economics and Finance*, 100101. https://doi.org/10.1016/j.dsef.2025.100101

[24] Parveen, S., Coccorese, P., Umer, M., & Tahir, A. H. (2025). Synergizing financial inclusion and green finance: advancing sustainable development goals 2030 and 2050 in alignment with COP 29 commitments. *Sustainable Development*, *33*, 48-76. https://doi.org/10.1002/sd.3553

[25] Nipa, N. N., Zahid, Z., Amin, M. R., Alamm, M. S., Haque, Z. M. E., & Parves, M. M. (2026). Harnessing Islamic FinTech for disaster risk financing: Innovative strategies for economic resilience and sustainable development. *Journal of Islamic Economics Lariba*, *12*(1). https://doi.org/10.20885/jielariba.vol12.iss1.art9

[26] Raut, B. B. (2025). Examining the Role of Microfinance Institutions in Enhancing Financial Inclusion and Economic Growth. *International Research Journal of MMC*, *6*(1), 1-14. https://doi.org/10.3126/irjmmc.v6i1.77155

[27] Appiah-Kubi, G., Tucker, J. J., Asongu, S. A., Goh, G. G. G., & Gyamfi, B. A. (2026). Exploring the role of microfinance institutions in promoting financial sustainability and alleviating poverty in Ghana. *Financial Innovation*, *12*(1), 15. https://doi.org/10.1186/s40854-025-00801-z

[28] Chandel, M., & Arora, M. (2025). Achieving the sustainable development goals through financial inclusion: a bibliometric and content analysis. *Tourism & Management Studies*, *21*(1), 21-37. https://doi.org/10.18089/tms.20250102