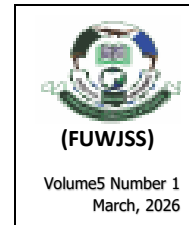


FORCED MIGRATION AND SCIENTIFIC KNOWLEDGE SUSTAINABILITY AMONG INTERNALLY DISPLACED WOMEN IN NORTHERN NIGERIA

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Abstract

Forced migration is a challenge to human capital preservation, especially in conflict-prone areas of the Global South. This study interrogates the sustainability of scientific knowledge among internally displaced women in Northern Nigeria, a region characterized by high rates of displacement. The study investigated the impact of forced migration on science education, retention of scientific knowledge, gender-based barriers to learning and participation in science during displacement and the adaptive strategies and support systems available to women. The research was guided by human capital theory and knowledge sustainability theory. A cross-sectional method was adopted to obtain data from a purposively selected sample of 279 internally displaced women and in-depth interview responses from 24 participants. Data analysis was through descriptive statistics and content analysis. Findings reveal that forced migration leads to significant disruption to science education among displaced women due to the collapse of educational institutions and lack of access to scientific resources; gender-based barriers to science education, practice, and transmission of knowledge include caregiving responsibilities, insecurity, limited access to targeted support schemes to rebuild scientific human capital, and cultural norms. Informal adaptive strategies adopted to promote scientific knowledge through peer learning, household practices and community roles appear precarious in the absence of institutional support. The study concludes that forced migration due to conflict and insurgency in Northern Nigeria systematically undermines women's scientific knowledge and skills. Gender-responsive educational and humanitarian interventions are critical for post-conflict recovery and inclusive development in affected regions.

Keywords: Forced migration, gender, science, IDPs, post-conflict recovery

Introduction

Forced migration has constituted one of the most prevalent global social problems in contemporary times, driven by the persistent occurrence of violent conflicts, political instability, environmental pressures, and climate-related disruptions in diverse spheres of life. It has become a persistent

phenomenon (IDMC, 2025). Forced migration is a movement characterised by an involuntary, compulsive, and coercive relocation to a place different from an individual's original abode or home. It is primarily driven by extreme violence, with people fleeing due to fear of attack, risk to life, and destruction of property (Ojiego-Okoro et al., 2024; Vincent, 2023; Mukhtar et al., 2018). These movements could be within or across a country. In 2024, more than 123 million persons were forcibly displaced, leading to involuntary migration. Such people often end up in internally displaced persons camps, where women and children become more vulnerable (UNHCR, 2024).

Beyond its immediate humanitarian effects, forced migration carries significant and lasting impacts on the development of human capital, social continuity, and the sustainability of knowledge systems (Idris et al., 2024; Ash & Solliner, 2019). It poses a threat to knowledge sustainability, professional practice, and intellectual engagement by dismantling educational institutions, disrupting educational processes and cognitive development, fragmenting social networks, and depriving learners of vital resources. Findings from other studies revealed that displacement increases the risk of a generational and systemic decline in knowledge sustainability, especially in science fields (Malynovska & Yatsenko, 2024; Upadhyay et al., 2017). Scientific knowledge, which comprises formal education in pure sciences, technical skills, and insights into health, environmental management, and technology. Historically, advancements in these areas have been critical for individual and societal development, fostering empowerment, innovation, and resilience (OECD, 2021).

Women, who make up a large share of displaced populations, experience forced migration in uniquely gendered ways that influence their access to education, skill development, professional progression, level of income, and socio-economic status (Bruck et al., 2024). Although there is an increasing body of research on displacement, forced migration, and gender, there has been insufficient focus on how forced migration impacts the sustainability of scientific knowledge among displaced women. The acquisition and application of knowledge promote continuity in scientific knowledge. Still, they are often undermined by prolonged displacement among women who experience limited access to educational resources, socio-cultural barriers, other gender-based vulnerabilities, and lack of institutional support in displacement environments (Beoku-Betts, 2008), such as Internally Displaced Persons (IDP) camps and host communities.

In many regions of the Global South, forced migration occurs within environments marked by fragile institutions, inadequate educational systems, deep-rooted gender inequalities, and conflict. These conditions increase the likelihood of displacement, which not only disrupts learning

processes and outcomes but also leads to a prolonged decline in scientific knowledge and skills. However, factors such as gender-based practices, caregiving responsibilities, a high level of insecurity, undue pressure to meet basic needs, limited resources and opportunities, and lack of access to advanced learning constitute barriers to women's engagement in science education, training, and practice during displacement (Bruck et al., 2024; Strelnyck & Shcherbina, 2023). The decline in scientific knowledge was observed in the 1970s (Cauwels & Didier, 2020). This also signals the erosion of human capital and generational knowledge, conditions that impede individual and institutional post-conflict recovery, and evidence-based governance (Balanzo et al., 2020). Thus, when women's opportunities for acquiring, maintaining, and transmitting such knowledge are disrupted, the implications extend beyond individual setbacks to societal issues of post-conflict recovery and inclusive development.

The experiences of women in Northern Nigeria present a crucial setting for investigating these dynamics. Since the early 2010s, the region has been most affected by forced migration due to the Boko Haram insurgency in the North-East, as well as banditry, conflicts between farmers and herders, communal violence, and climate-related challenges in livelihoods across the North-West and parts of the Middle Belt. These crises created one of the largest populations of internally displaced persons in Africa, with Nigerians representing over 80% of the IDPs in 2023 (IOM, 2023; IDMC, 2023). Increasing displacement rates and limited opportunities for enduring solutions are reported (Kanu et al., 2020). For instance, 2.27 million IDPs from 468,103 households in the North-east region of Nigeria were identified by IOM DTM Nigeria Round 47 (2024). Women and children represent the majority of internally displaced persons, with their experiences shaped by pre-existing disparities in education, labour market involvement, and sociocultural norms (Chiri et al., 2025).

Displacement in Northern Nigeria has received significant attention from researchers, particularly in the areas of security, humanitarian activities, livelihoods, and gender-based violence. Furthermore, previous studies on education during emergencies have tended to focus on access to basic education and psychosocial support. Such studies often view learning as a temporary humanitarian measure rather than an enduring process of knowledge retention and transmission. As a result, the cumulative impacts of forced migration on women's scientific knowledge trajectories, such as disruptions to secondary and higher education, loss of technical skills, degradation of professional identities, and severance from scientific networks, remain insufficiently explored. This knowledge gap is germane considering the importance of science-related knowledge in environments affected by displacement.

Based on the foregoing, this paper aims to examine the impact of forced migration on the sustainability of scientific knowledge among displaced women in Northern Nigeria. It focuses on assessing how forced migration affects science education among these women, the use and retention of scientific knowledge, gender-based barriers to participating in science during displacement, and the adaptive strategies and support systems accessible to women. The paper argues that displacement diminishes women's scientific knowledge base, driven by institutional collapse, material disadvantages, and gender-based social constraints, while also prompting adaptive practices often ignored by development policies. This study adds to the literature on forced migration, gender, and development, highlighting the importance of inclusive humanitarian and educational policies to protect and rebuild scientific knowledge among displaced women.

Conceptualising Forced Migration and Knowledge Sustainability

Forced migration is conceptualised as the involuntary movement or relocation of individuals/communities occasioned by violent conflicts, environmental disasters, or other crises that threaten safety and livelihoods (UNHCR, 2023; Karkar, 2019). The term is commonly used to describe the movement of displaced persons, refugees, and victims of trafficking (IOM Glossary on Migration, 2019). Forced migration is different from voluntary migration, which is predominantly influenced by personal choice. Forced migration, on the other hand, is characterised by urgency, lack of individual choice, and higher risks. It is greatly influenced by the strength of the push factor and often linked to a controlling social organization, which has an overpowering effect on the movements of displaced persons, thereby reducing their decision-making power. One distinguishing characteristic is that forced migrants are more inclined to retain or reestablish their previous conditions, such as skills and careers, unlike voluntary migrants whose life choices are influenced by other push factors (Oliver-Smith & Hansen, 2019).

Globally, 117.3 million people flee their homes involuntarily due to wars/violent conflicts, climate change, natural disasters, and economic and political challenges. Out of this population, 67.8 million are internally displaced (Doctors Without Borders, 2025). Factors such as physical violence, weak governance, and socio-political deficiencies collectively produce large-scale displacement. Women and children constitute a high percentage of IDPs, and this predisposes them to unfavourable experiences and disproportionate challenges (Chiri et al., 2025; Brück et al., 2024).

The disruptions caused by forced migration extend beyond physical displacement; they also impact social structures and access to quality education, particularly in science (Idris et al., 2024; Ash & Solliner, 2019).

Scientific knowledge includes practical and theoretical skills and competencies needed for effective participation in fields such as healthcare, environmental management, agriculture, and technology. Therefore, formal education and hands-on learning experiences develop scientific knowledge, which is supported by ongoing practice, adequate resources, and certification within institutional or professional networks. Knowledge in technical, pure, and natural sciences is socially created and context-dependent, relying on opportunities for long-term learning, mentorship, and institutional support. Scientific knowledge and practice are therefore integral parts of social life, which drive the digital functioning of society and foster social transformation and development, and other problems of society (Pashchenko, 2025; Koshelev & Ivchekova, 2022). This makes scientific knowledge sustainability critical to human capital development.

The concept of knowledge sustainability is often used in formal organizations. Knowledge sustainability describes the ability of individuals, communities, organisations and institutions to develop, preserve, adapt, and pass on knowledge continually. It showcases an organization's capacity to develop critical knowledge that would meet the needs of future generations by preserving, transferring, and effectively managing it, while keeping it relevant and adaptable. The importance of sustainable knowledge is acknowledged by Bencsik (2022), who argues that it improves market performance and internal resource utilization. Therefore, identifying and preserving core organizational knowledge, especially for generational benefits, was emphasised by Vágner and Bencsik (2022). Core features of knowledge sustainability include the use of effective information technology tools, uninterrupted learning processes and adaptation, and ethical knowledge sharing and practices. Jorna et al. (2009) further explained that for an organization to be sustainable, it must have both knowledge of its impacts and the ability to learn, renew, and innovate in response to environmental challenges. These features make knowledge sustainability in science essential to individuals, communities, and societies.

Empirical Review

The influence of forced migration on scientific knowledge production creates unique experiences for individuals, homes, and host communities. Studies on the impact of forced migration on scientific knowledge span different areas and periods, revealing that a consistent pattern of knowledge development promotes the sustainability of knowledge. Forced migration experiences motivate individuals to act, leading to the creation and sharing of knowledge that benefits the host community. For example, forced migration alters how scientific knowledge develops among displaced academic scientists. They become more actively involved in knowledge

development rather than passive recipients. Therefore, migrant teachers are often intentional in their resolve to effectively navigate and adapt to their new environments by engaging in intellectual activities (Donovan et al., 2025). This supports earlier findings by Gallo (2024), who emphasises the important roles of academic refugees in advancing scientific knowledge in their host country.

However, significant research findings show that forced migration limits human capital development and career growth by disrupting educational processes and cognitive development. This leads to serious consequences for displaced children and communities, according to Ager and Strang (2008), who studied how integration influences the resettlement of refugees and migrants by sampling refugee settlements in the UK. Education was identified as a key area of integration; however, barriers such as language, culture, and the local environment affected refugees' access to education. Dryden-Peterson (2016) also examined how to achieve the universal right to education and opportunities to apply acquired knowledge. Data from documents and interviews revealed that implementation processes and requirements can limit migrants' ability to access education, practice, and contribute to society.

UNHCR (2021) reports that skills and labour market transitions for refugees and host communities reveal that Uganda's economy is mostly informal and self-employed. This makes it difficult to meet diverse market demands, especially for forced migrants in settlements. Using previous skills is challenging for them due to the lack of verified documents for their current education and skills, and because their skills are only recognized in their home country. Many male graduate migrants either become self-employed or shift to other informal technical fields like carpentry and construction. Meanwhile, women tend to become self-employed in hairdressing, tailoring, and beauty salons. This indicates that, over time, there will be a decline in certain knowledge and skills, including scientific knowledge, among the migrants.

In another study conducted by Ash and Solliner (1996), multiple case studies and disciplinary analysis were adopted to examine the impact of migration on different fields of science education. The study concluded that significant changes occurred in scientific disciplines and practices in host communities due to the influence of German migrants on schooling. This implies that a depletion of scientific knowledge or brain drain is experienced in the country of origin following their relocation. Furthermore, Idris et al. (2024) investigated the impact of war on science education and scientists. Findings revealed that Sudan's education sector experienced a severe downturn due to a protracted war during which many scientists were displaced, in addition to loss of resources, and shutdown of institutions of

higher learning. Collectively, these factors adversely impacted the scientists and the quality of science education. This corroborates Upadhyay et al., (2017) finding that children from migrant households performed poorly in cognitive tests, with statistically significant reductions in math, reading, and memory performance.

Beoku-Betts (2008) studied how four female migrant scientists from Sierra Leone adapted their lives and careers to meet the dynamic needs of their home country, influenced by their political and economic conditions. Semi-structured interview responses captured the lived experiences and perspectives of the participants. The findings revealed that despite migrating, these women kept strong emotional ties with Sierra Leone, which continued to influence their scientific work, commitments, and contributions to their homeland. The analysis references brain drain discourse, transnationalism concepts, and feminist research on gender and migration. The study highlights how these women's experiences as transnational migrants are affected by inequalities of gender, race, and nationality, along with evolving economic, social, and political changes in both their origin and destination countries. These conditions both restrict and provide opportunities for them to compete, challenge, and navigate new areas of experience. However, many of these prospects are disrupted by circumstances in other environments hosting internally displaced women, where women often lose access to professional communities, laboratories, and classrooms, all essential for maintaining and utilizing scientific knowledge. Invariably, structural and socio-economic barriers that limit women's participation in education are reflected in gendered access.

There has been a plethora of empirical research on the interplay among forced migration, gender, and knowledge retention; however, there are few studies that have given attention to the scientific knowledge of displaced women in Northern Nigeria. For instance, Pulda and Rwang (2022) investigated how increasing insecurity influences the level of female children's enrolment in school and their commitment from 2014, a study of the Chibok and Dapchi abductions in North-East Nigeria. The study reported that due to the Boko Haram insurgency, girls' education in North-East Nigeria, secondary and tertiary education, is severely disrupted by ongoing conflict and displacement. The study demonstrated that insecurity undermines the ability of a girl child to achieve educational growth. Together, these findings show that relocation poses a significant threat to knowledge continuity and sustainability in addition to being a humanitarian emergency.

Forced migration poses several challenges to knowledge sustainability in science, as individuals are suddenly displaced from schools, workplaces, and communities, thereby disabling effective knowledge transfer and

retention. This condition is exacerbated since the effectiveness of knowledge sustainability depends on institutional support, mentorship, and adequate resources that are often inadequate in long-term displacement. Moreover, women face disproportionate educational and skill-related disadvantages because of gendered norms and responsibilities. Such constraints increase the risks of knowledge loss and prevent women from fully participating in STEM skills, training, and professional advancements during displacement. Despite the empirical revelations, there is a dearth of studies that particularly focused on the experiences of displaced women in Northern Nigeria.

Theoretical Framework

The theoretical frameworks adopted for this study are the **Human Capital Theory** and **Knowledge Sustainability Theory**, which provide an understanding for assessing the impact of forced migration on the transmission and retention of scientific knowledge among displaced women. Becker (1964) reveals that knowledge, skills, and education are forms of human capital that empower individuals and facilitate access to well-paid formal sector jobs, leading to social advancement and mobility. Formal education, career training, and practical experiences contribute to the development of human capital, required for social resilience, economic advancement, and innovativeness to meet dynamic environments. Human capital formation depletes in locations where displacement occurred due to interference with formal educational processes, limited access to resources, and weak professional networks.

The concept of Knowledge Sustainability, on the other hand, highlights how individuals, groups, and organisations preserve, restructure, and transfer information over time. The concept is founded on knowledge management and organizational learning theories, as espoused by UNESCO (2005); Sveiby (1997); Nonaka & Takeuchi (1995); and Senge (1990) knowledge sustainability frameworks. Sustainable knowledge encompasses the skills and knowledge that are learned, transmitted, and passed through generations. It is not only about preserving knowledge, but involves fostering an enabling ecosystem for knowledge cultivation, transmission, and application to meet the needs of society (2024 Sustainability Directory). The fundamentals for retaining professional skills and knowledge include the ability to access opportunities for practical applications and learning materials, other relevant resources, and institutional support, as highlighted by the concept of knowledge sustainability. Meeting social, economic, and environmental needs, therefore, requires that scientific knowledge be preserved, accessible, and applied responsibly for generational wellbeing.

This study proposes that forced migration emanating from displacement limits access to educational opportunities, disrupts educational processes

and professional engagements, thus hindering the acquisition and preservation of scientific knowledge for displaced women in Northern Nigeria, with implications for both individual growth and societal wellbeing.

Research Methodology

This study utilized a mixed-method cross-sectional design comprising a questionnaire and semi-structured interviews to investigate the effects of forced migration on the sustainability of scientific knowledge of women who have fled their homes in Northern Nigeria. The target population for data collection consists of women, ages 18 and over, who are currently living in designated internally displaced persons (IDP) camps or host communities across Borno State (North-East), Kaduna State (Northwest), and Benue State (North Central). These three states were purposively selected because they have the highest displacement rates due to the ongoing violent conflict and insurgency in Northern Nigeria. Respondents were identified using both purposive and snowball sampling methods.

The sample population for this study was 400 participants who had experience in or were interested in science-related education, training, or development of science-based skills before displacement. Data were gathered using a structured questionnaire that measured four constructs on a five-point Likert scale of Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), and Strongly Disagree (SD). In-depth interviews were also conducted with twenty-four (24) participants who were part of the sample population, to provide insightful data and context for the survey results. Eight (8) interviewees were selected from each region based on their level of education and duration of forced migration. Both the questionnaire and interviews were administered with the help of competent research assistants who translated the instruments into the respondents' local languages whenever necessary, thereby solving the problem of language barrier and comprehension.

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to analyze the quantitative data. Cluster means helped explore overall patterns across different constructs. Internal consistency was evaluated with Cronbach's alpha, and all constructs showed excellent reliability ($\alpha > .97$). The table below shows the results:

Table 1: Cronbach's Alpha Reliability of Data Collection Instrument

<i>Scale (Table)</i>	<i>No. of Items</i>	<i>Cronbach's Alpha</i>	<i>Interpretation</i>
Impact of Forced Migration on Education and Learning (Table 4)	5	0.992	Excellent
Knowledge Sustainability and Retention (Table 5)	5	0.974	Excellent

Gendered Barriers and Access to Learning (Table 6)	5	0.991	Excellent
Adaptive Strategies and Support Systems (Table 7)	5	0.973	Excellent

Source: Field Data, 2025

Additionally, qualitative interview data were analyzed using content analysis and incorporated into the quantitative results analysis to deepen interpretive insights. The study adhered to ethical standards by obtaining informed consent, confidentiality, anonymity, and voluntary participation, in line with best practices for research involving displaced and vulnerable populations.

Results/Findings and Discussion

Questionnaire Distribution

Table 2: Presentation of Questionnaire Distribution

<i>S/N</i>	<i>Variables</i>	<i>Frequency</i>	<i>Percentage</i>
1	Number Distributed	400	100
2	Number Returned/Collated	279	70
3	Number Unreturned	121	30

Source: Survey, 2025

The presentation above is the distribution of questionnaire across the sample area. The sample area received a total of four hundred (400) copies of the questionnaire. A total of two hundred and seventy-nine (279) copies of the questionnaire were duly completed and returned, representing seventy percent (70%), while one hundred and twenty-one (121) copies of the questionnaire, representing thirty percent (30%), were not returned. It therefore implies that over two-thirds of the questionnaire was retrieved.

Table 3: Presentation of respondents' demographic information

S/N	Variable	Category	Frequency	Percentage
1	Age	18-24	68	24.4
		25-34	112	40.1
		35-44	68	24.4
		45-Above	31	11.1
		Total	279	100
2	Marital Status	Single	42	15.1
		Married	188	67.4
		Widowed	38	13.6
		Divorced/Separated	11	3.9
		Total	279	100
3	Educational Level before Displacement	No formal education	25	9.0
		Primary Education	48	17.2
		Secondary Education	112	40.1
		Tertiary Education	85	30.5
		Postgraduate	9	3.2
		Total	279	100
4	Pre-Displacement Science Engagement/Potential Candidates	Health-related (nursing, midwifery, etc.)	90	32.3
		Agriculture/Environmental Education/Science	72	25.8
		teaching	62	22.2
		Technology/Engineering	20	7.2
		Other applied sciences	10	3.6
		Potential science education candidates	25	9.0
		Total	279	100
5	Region of Displacement	North-East	142	50.9
		North-West	88	31.5
		North-Central	49	17.6
		Total	279	100
6	Duration of Displacement	Less than 2 years	35	12.5
		2-5 years	98	35.1
		6-10 years	104	37.3
		Above 10 years	42	15.1
		Total	279	100
6	Location Type	Formal IDP Camp	156	55.9
		Host community/informal settlement	123	44.1
		Total	279	100

Source: Field Data, 2025

The demographic profile of the 279 respondents in Table 3 shows a sample of internally displaced women who are mostly in their reproductive and economically active years. Of these, 64.5% are between the ages of 25 and 44, and 67.4% are married, while 13.6% are widowed. This age and marital distribution reveal increased risks because married and widowed women often take on more caregiving duties, which further research confirms as a major obstacle to maintaining scientific knowledge. Over 70% of respondents had completed secondary or postsecondary education before their displacement, and 254 of them were involved in science-related activities, mainly in the fields of health (32.3%), agriculture/environmental management (25.8%), and science teaching (22.2%). Additionally, 25 women (9%) expressed a desire to engage in science education. This indicates that the sample represents a significant reservoir of human capital at risk, consisting of women whose scientific skills are vital for household survival and community resilience in displacement locations.

With half (50.9%) coming from the North-East, the epicenter of the Boko Haram conflict, followed by the North-West (31.5%) and Middle Belt (17.6%), the sample's geographic and age distributions reflect the persistent character of Northern Nigeria's displacement situation. Furthermore, over 90% have been displaced for more than two years, including 52.4% who have been displaced for six or more years. Respondents are divided between host communities (44.1%) and formal IDP camps (55.9%). On the whole, these demographics show that a representative group of educated, science-engaged women is experiencing protracted challenges in one of Africa's biggest internal displacement crises.

Table 4: Impact of Forced Migration on Education and Learning

S/N	Variables	SA (%)	A (%)	N (%)	D (%)	SD (%)	Mean	Std. Dev.
1	Forced migration has interrupted my formal science education	121 (43.4)	99 (35.5)	23 (8.2)	14 (5.0)	22 (7.9)	4.04	1.13
2	Displacement has caused loss of access to scientific learning resources.	112 (40.1)	97 (34.8)	37 (13.3)	8 (2.9)	25 (9.0)	4.00	1.07
3	Conflict led to the closure/destruction of the educational institutions I attended.	133 (47.7)	93 (33.3)	23 (8.2)	8 (2.9)	22 (7.9)	4.15	1.05
4	I have experienced long-term gaps in scientific learning due to displacement.	129 (46.2)	90 (32.3)	30 (10.8)	10 (3.6)	20 (7.2)	4.10	1.08
5	Forced migration makes continuing science education difficult.	118 (42.3)	100 (35.8)	37 (13.3)	9 (3.2)	15 (5.4)	4.09	1.03
	Cluster Mean						4.08	

Source: Field Data, 2025

Forced migration significantly changes educational trajectories in science disciplines, as shown in Table 4. More than 75% of respondents agreed or strongly agreed with all the options, leading to a high cluster mean of 4.08 (on a scale where 5 = Strongly Agree), suggesting a high consensus view of disruption. The highest-rated question, "Conflict led to closure/destruction of educational institutions I attended" (Mean = 4.15; 81.0% agreement), accurately captures the institutional and material disruption brought about by the Boko Haram insurgency, banditry, and inter-communal violence in Northern Nigeria. Similar to this, long-term learning gaps (Mean = 4.10) and interrupted formal education (Mean = 4.04) highlight how dislocation turns short-term setbacks into long-term degradation of human capital. Although destruction of physical infrastructure received the highest acceptance, the lack of teaching and learning materials exacerbates the challenge, according to the slightly lower (but still high) agreement on loss of access to resources (Mean = 4.00).

Interview responses illustrate how this disruption goes beyond temporary schooling gaps to create an enduring educational rupture and distance from home:

"When the school and laboratory were destroyed, my science education to qualify as a midwife ended there. Even when I reached the camp, there was no place to continue from where I stopped. I have not returned to my hometown since I was forced to leave five years ago (Participant 2, Nurse, aged 25)."

"Science is not like other areas of study; once you leave it for long, you lose direction. Displacement did not just stop my learning; it disconnected me from my home, where I intended to help my people in the community health centre (Participant 5, medical student, aged 22).

In addition, girls who desired a science education after secondary school were prevented from achieving it due to the destruction of educational facilities, disruption in academic processes, and forced migration; a finding that aligns with Pulda and Rwang (2022) opinion that insecurity and displacement limit a girl's access to educational development in Northern Nigeria. A participant states:

"I always wanted to go for a science course after secondary school, but we left our house in a hurry. We were accommodated by my father's friend in another state. I didn't go back to school because my father forced me to marry his friend's son. I wanted to become an expert in agriculture (Participant 10, Potential science education candidate, aged 25).

The above results revealed that forced migration systematically erodes the institutional underpinnings necessary for displaced women to access education and acquire scientific knowledge. This finding aligns with Idris

et al. (2024) and Ash & Solliner (2019) who maintained that forced migration leads to long-term decline in quality science education due to institutional collapse.

Table 5: Scientific Knowledge Sustainability and Retention

<i>S/N</i>	<i>Variables</i>	<i>SA (%)</i>	<i>A (%)</i>	<i>N (%)</i>	<i>D (%)</i>	<i>SD (%)</i>	<i>Mean</i>	<i>Std. Dev.</i>
1	I have retained most of my pre-displacement scientific knowledge.	25 (9.0)	38 (13.6)	66 (23.7)	45 (16.1)	105 (37.6)	2.62	1.17
2	Displacement has caused erosion of my scientific skills due to lack of practice.	104 (37.3)	118 (42.3)	31 (11.1)	11 (3.9)	15 (5.4)	4.04	1.03
3	I regularly apply scientific knowledge in community or household activities.	117 (41.9)	92 (33.0)	45 (16.1)	10 (3.6)	15 (5.4)	4.04	1.06
4	My scientific knowledge is at risk of loss without support.	131 (47.0)	99 (35.5)	27 (9.7)	4 (1.4)	18 (6.5)	4.20	0.96
5	It is hard to update scientific knowledge during prolonged displacement.	131 (47.0)	96 (34.4)	22 (7.9)	12 (4.3)	18 (6.5)	4.13	1.08
	Cluster Mean						3.81	

Source: Field Data, 2025

A more nuanced picture is reflected in Table 5, where a cluster mean of 3.81 indicates both partial resilience and moderate-to-high anxiety about knowledge degradation. "My scientific knowledge is at risk of loss without support" (Mean = 4.20; 82.5% agreement) and "It is hard to update scientific knowledge during prolonged displacement" (Mean = 4.13; 81.4% agreement) are two items with extremely high levels of agreement. The vulnerability of knowledge sustainability in long-term displacement is highlighted by these answers. The lack of practice that results in skill erosion (Mean = 4.04; 79.6% agreement) further demonstrates how scientific competences, which depend on ongoing application and institutional support, quickly decline in the absence of supportive contexts. The lowest mean, "I have retained most of my pre-displacement scientific knowledge" (Mean = 2.62; just 22.6% agreement), on the other hand, shows a substantial loss of self-perceived knowledge.

Nevertheless, a key adaptive trait is evident from the strong agreement on the regular use of community and household engagements (Mean = 4.04; 74.9% agreement): women consistently apply residual scientific knowledge in real-world situations (e.g., health, hygiene). Knowledge Sustainability Theory's focus on adaptive practices under constraints is illustrated by this

dichotomy, which highlights their vulnerability without formal reinforcement. Furthermore, while undermining formal knowledge sustainability, it is maintained through informal application. Most of the interview participants reported that they relied on some of the residual scientific knowledge obtained through informal mechanisms. Interview responses clarify this narrative:

“I still remember some things I learned as a health worker, but without practice and training, I am no longer confident in my knowledge” (Participant 3, Health worker, aged 40).

“I use what I know for small health and hygiene issues, but I know it is outdated. There is no way to improve on it here” (Participant 12, Health science teacher, aged 35).

My teaching profession at the University was disrupted for over five years, and this affected my promotion because I could not meet the requirements. Many students dropped out of school and never went back. You can’t transmit knowledge when there are no opportunities to impart what you know. I usually organize tutorials for displaced persons who wish to learn something” (Participant: 9, Lecturer, aged 30)

Thus, knowledge sustainability, which involves the ability of individuals, communities, and institutions to preserve, adapt, and pass on knowledge over time, becomes challenging during forced migration. The findings of this study showed a significant loss of scientific knowledge among displaced women. Most of the participants agreed that they had lost many scientific skills because they had not been able to practice what they learned, and did not have access to updating mechanisms. Furthermore, it was also revealed that some female scientists often apply some of their residual scientific knowledge through informal mechanisms to manage health and hygiene cases, in the absence of formal opportunities to practice. This finding agrees with Vagner and Bencsik 2022) and Jorna et al. (2009), who state that knowledge is sustained only by continuous learning, validation, and renewal. Invariably, regular informal application of knowledge allows an individual to postpone a total loss of acquired knowledge, but with the risk of a gradual degradation of skills.

Moreover, the worth of residual knowledge is often undermined by an individual’s lack of confidence in her ability to transfer and retain knowledge. This experience is often observed among migrants who are compelled to switch to other informal occupations, either in the technical fields or become self-employed in non-scientific fields such as catering, tailoring, and hairdressing. This finding corresponds with the reports from UNHCR (2021) and Upadhyay et al. (2017), that prolonged time away from

school or work causes a measurable decline in cognitive and skill-based competencies in technical areas.

Table 6: Gendered Barriers and Access to Learning

<i>S/N</i>	<i>Variables</i>	<i>SA (%)</i>	<i>A (%)</i>	<i>N (%)</i>	<i>D (%)</i>	<i>SD (%)</i>	<i>Mean</i>	<i>Std. Dev.</i>
1	Cultural norms limit women's participation in science learning during displacement.	115 (41.2)	106 (38.0)	27 (9.7)	11 (3.9)	20 (7.2)	4.05	1.07
2	Caregiving responsibilities hinder attendance at learning programmes.	137 (49.1)	81 (29.0)	32 (11.5)	10 (3.6)	19 (6.8)	4.13	1.09
3	Insecurity restricts mobility for accessing education.	127 (45.5)	96 (34.4)	25 (9.0)	6 (2.2)	25 (9.0)	4.12	1.04
4	Early marriage affects the continuation of science education.	131 (47.0)	84 (30.1)	38 (13.6)	11 (3.9)	15 (5.4)	4.11	1.08
5	Camp programmes favour advanced learning for men more than women.	128 (45.9)	110 (39.4)	17 (6.1)	5 (1.8)	19 (6.8)	4.21	0.95
	Cluster Mean						4.12	

Source: Field Data, 2025

The highest cluster mean of 4.12, as indicated in Table 6, reveals that gender-based structural barriers worsen the impact of forced migration on displaced women's scientific knowledge. "Camp programmes favour advanced learning for men more than women," which received the highest response rate (Mean = 4.21; 85.3% agreement), shows the institutionalized nature of gender discrimination in humanitarian education programming. Other barriers grounded in feminist political economy and intersectionality frameworks are identified as caregiving responsibilities (Mean = 4.13; 78.1% agreement), insecurity that limits mobility (Mean = 4.12; 79.9% agreement), early marriage (Mean = 4.11; 77.1% agreement), and cultural norms (Mean = 4.05; 79.2% agreement). These results highlight how displacement intersects with prevalent patriarchal practices in the Northern part of Nigeria, to create unfavourable conditions. This implies that women are not only displaced but also contend with systemic exclusion from opportunities to rebuild their scientific human capital. The results show common experiences across the sample based on the consistently high means and low variances (SDs around 1.0), further revealing the systemic nature of these barriers. Interview responses provide insight into how these barriers operate in everyday displacement settings:

"There was a time one organisation came to the camp and asked us to gather in one small hall to learn a skill, but I was always busy with my mother, taking care of our space and younger siblings. My father and elder

brother joined them. In fact, my father told me that the training was not for girls. Science programmes are not designed with us in mind” (Participant 15, secondary school student, aged 18)

“They choose men for advanced learning because they believe women will marry or stop working. That belief follows us even into the camp (Participant 11, Graduate, aged 24).

Evidence on how forced migration elevates gendered barriers to scientific learning are captured in Table 6 and the IDI responses. The high level of agreement across all gender-related indicators demonstrates that there are shared experiences of exclusion, and that exclusion is rooted in caregiving burden(s), insecurity, early marriage, and cultural norms. The accounts provided indicate that women are generally excluded from scientific opportunities by the combined influence of both patriarchy and displacement. This finding aligns with the feminist political economies, which argue that traditional gender roles and expectations will be reinforced during crises, while either maintaining or intensifying unequal access to resources (Brück et al., 2024). The priority given to male participants in camp-based programmes reveals entrenched gender bias within institutions, which supports Chiri et al. (2025), who argue that pre-existing inequalities in education, labour market engagement, and sociocultural practices do not favour women. On the other hand, Beoku-Betts (2008) asserts that women’s transnational migration experiences are significantly influenced by gender inequalities, economic and power dynamics, and social norms that restrict their progress with regard to their scientific endeavours.

Table 7: Adaptive Strategies and Support Systems

<i>S/N</i>	<i>Variables</i>	<i>SA (%)</i>	<i>A (%)</i>	<i>N (%)</i>	<i>D (%)</i>	<i>SD (%)</i>	<i>Mean</i>	<i>Std. Dev.</i>
1	I use scientific knowledge for health and hygiene in the household.	111 (39.8)	88 (31.5)	50 (17.9)	7 (2.5)	23 (8.2)	3.98	1.06
2	Peer learning helps sustain scientific knowledge among women.	110 (39.4)	83 (29.7)	52 (18.6)	15 (5.4)	19 (6.8)	3.91	1.15
3	Community roles allow the application of scientific skills.	111 (39.8)	94 (33.7)	52 (18.6)	7 (2.5)	15 (5.4)	4.03	1.01
4	NGOs provide adequate science-related training and support.	30 (10.8)	48 (17.2)	61 (21.9)	55 (19.7)	85 (30.5)	2.69	1.26
5	Policies effectively support displaced women's scientific knowledge.	40 (14.3)	43 (15.4)	65 (23.3)	55 (19.7)	76 (27.2)	2.77	1.32
	Cluster Mean						3.48	

Source: Field Data, 2025

The lowest cluster mean (3.48) appears in Table 7, which presents a mixed picture: there are significant gaps in institutional support but strong evidence

of grassroots adaptation. Items related to health and hygiene application (Mean = 3.98; 71.3% agreement), community roles that promote skill use (Mean = 4.03; 73.5% agreement), and peer learning (Mean = 3.91; 69.1% agreement) show relatively high scores on personal and community-level adaptation. However, opinions on external help are significantly negative: "NGOs provide adequate science-related training support" (Mean = 2.69; only 28.0% agreement) and "Policies effectively support displaced women's scientific knowledge" (Mean = 2.77; 29.7% agreement) reveal a gap in implementation. The gap between humanitarian rhetoric or expectations during emergencies and actual service delivery, mostly in education, is evidenced by the level of disagreement with the propositions.

Displaced women find various ways to cope with obstacles to promote scientific knowledge through peer learning, household practices, and community roles. Findings show a mix of resilience and frustration about how little they can achieve with what they have. Without sufficient opportunities to learn, practice, and share knowledge, they depend on each other to exchange scientific skills and information but struggle to go beyond what they already know, with one respondent saying they are 'just recycling old knowledge.

The adaptive practices outlined earlier, which are based on Knowledge Sustainability Theory's focus on social learning, support the idea of shared learning. However, the results for NGO support and policy effectiveness are very low, highlighting a significant challenge to these informal practices and indicating that informal resilience has yet to be supported by institutions. The large gap between them reflects critiques in education-in-emergencies scholarship, which suggests that humanitarian responses often prioritize short-term survival activities over advanced or scientific learning (Dryden-Peterson, 2016). Consequently, the long-term sustainability of women's adaptive practices is likely to be at risk due to inadequate support systems for their ongoing development and use. This demonstrates resilient informal adaptation despite limited formal support and reinforces the argument that current policy frameworks fail to recognize or build on women's adaptive practices, leaving knowledge sustainability fragile and hindering human capital recovery.

Overall, these results support the main thesis of the paper, which is that forced migration systematically erodes the institutional underpinnings necessary for displaced women to acquire and preserve scientific knowledge. By measuring the gendered aspects of human capital loss in one of Africa's biggest internal displacement crises and emphasising women's agency in knowledge retention despite systemic deficiencies, these findings close a significant empirical gap.

Conclusion and Recommendations

This research examined how forced migration has impacted scientific knowledge preservation among internally displaced women in Northern Nigeria. By combining Knowledge Sustainability Theory and Human Capital Theory, this study provides an understanding of the impact of forced migration on the sustainability of scientific knowledge among internally displaced women in Northern Nigeria. The study concludes that forced migration caused by conflict and insecurity systematically undermines internally displaced women's scientific skills through sudden disruptions to educational institutions and processes, limited access to educational resources, and worsened gender-specific barriers such as caregiving duties, programme biases, and limited mobility. Nevertheless, women display strong resilience despite this decline by actively using residual knowledge in informal family and community settings with adaptive behaviours and peer learning, among other strategies.

The study challenges humanitarian frameworks that promote short-term basic education over advanced scientific continuity by exposing the cycle of formal disintegration compensated by brittle informal resilience. In the end, protecting the scientific knowledge of displaced women is crucial for resilient development in Northern Nigeria, institutional reconstruction, and wider post-conflict recovery, in addition to gender equity.

Based on the empirical evidence and theoretical insights, the following evidence-based recommendations are proposed for policymakers, humanitarian actors, development partners, and researchers:

- i. Mandate that education-in-emergencies programmes for IDP camps and host communities include advanced science-focused modules (such as health, environmental management, and agriculture), with flexible delivery, mobile resources, and clear measures to guarantee women's equitable participation and accommodation of caregiving responsibilities;
- ii. Create pathways for skill validation and certification that acknowledge practical knowledge used in home and community contexts (such as water management and hygiene), while assisting peer-learning networks with training-of-trainers programmes to turn informal resilience into recognised competencies;
- iii. Take specific actions, such as providing safe transportation and childcare, strengthening security surrounding educational facilities, conducting gender audits of programmes to remove prejudice, and launching community campaigns to address cultural norms, early marriage, and patriarchal limitations on women's education;

- iv. Align humanitarian relief with long-term human capital rebuilding by incorporating scientific knowledge preservation for displaced women into national IDP policies and frameworks for durable solutions, with special funding for STEM continuation programmes coordinated across governments, UNHCR, IOM, and UN Women;
- v. To leverage displaced women's knowledge for community resilience and post-conflict development, encourage regular gender-disaggregated data collection on scientific skills in displacement assessments, longitudinal research to assess interventions, and cross-sectoral partnerships (education, health, agriculture, women's networks).

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