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Original Research

Effect of the Great Green Wall Initiatives on Livelihood Capitals of Households in the Frontline States in Nigeria

Balogun Cecy Edijala[1,*]

[1] Centre for the Study of Race, Gender and Class, Humanities Faculty, University of Johannesburg, Johannesburg 2092, South Africa
[*] Corresponding author: cbalogun@uj.ac.za

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Abstract

The Great Green Wall interventions of the National Agency for the Great Green Wall in Nigeria represent a critical response to the dual challenges of climate change and socio-economic instability. As desertification and land degradation continue to threaten the livelihoods of millions, these interventions aim to provide social protection by enhancing resilience to environmental shocks and improving livelihoods in affected communities. This study analysed the effects of these initiatives on the livelihoods of vulnerable communities in selected frontline states along the Sahel region of Nigeria. It raises questions about how the agency's initiatives have influenced respondents' livelihood capital and whether there is a difference in the livelihood capital of beneficiaries and non-beneficiaries. Utilising a quantitative approach, the research purposively selected 262 respondents from Gombe, Kebbi and Sokoto states on whom structured questionnaires were administered to understand how the interventions affected their livelihood capital. The data were analysed using regression analysis and means. The study revealed that the agency's interventions significantly influenced beneficiaries' livelihood capital, as evidenced by the significant difference in livelihood capital post-intervention. The effect varies across livelihood capital ($t = 9.75$ for physical, $t = 6.55$ for human, $t = 6.85$ for financial, $t = 7.69$ for social, and $t = 4.33$ for natural). The livelihood capital of beneficiaries also increased relative to that of non-beneficiaries, highlighting how social welfare intervention programs can improve climate resilience for communities affected by climate change.

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Statement of Sustainability: This study is novel in its comprehensive, comparative analysis of how Great Green Wall interventions affect all five livelihood capitals: physical, human, financial, social, and natural rather than examining isolated outcomes. The study is important because it assesses whether environmental restoration initiatives translate into tangible, sustainable welfare gains for rural households. It contributes to knowledge by operationalising the sustainable livelihoods framework for impact evaluation and by generating context-specific evidence relevant to the achievement of the SDGs, particularly SDGs 1 (No Poverty), 2 (Zero Hunger), and 13 (Climate Action).

1. Introduction

Climate change casts a long shadow on Nigeria's Sahel region, driving environmental degradation, disrupting livelihoods, and displacing communities. The impact of climate change on Nigerian rural families is dire, creating shifts in livelihood patterns and alternatives, a problem that is particularly precarious in the frontline states along the Sahel region in the country. The problems of land and environmental degradation due to climate change are not peculiar to Nigeria, most African countries in the Sahel region are seriously affected, and regional measures have been explored to address the problem. In response to escalating land degradation and desertification pressures, several global and regional initiatives have emerged. Among the most prominent is the Great Green Wall Initiative (GGWI), launched in 2007 by the African Union.

From a global perspective, the African Sahel region is among the areas hardest hit by land degradation and desertification, driven by climate change and poverty (Nkonya et al., 2016). Desertification in the region is expanding, increasing by 8% between 1950 and 2015, leading to the displacement of communities and the loss of diverse ecosystems (Liu & Xue, 2020). According to Coulibaly et al. (2020), the expansion of the Saharan desert has implications for the millions living in the region who rely on rain-fed agriculture

and face significant economic constraints in adapting to this evolving climate. In response to environmental degradation driven by desert encroachment and fluctuating rainfall patterns, with increasing flood incidents, eleven African countries, including Nigeria, initiated the Great Green Wall (GGW) project to combat land degradation. Championed by the African Union, the initiative aimed to reduce the impact of global warming that manifests in extreme poverty, food insecurity, forced human displacements, resource-based conflict and other social vices (Gwaza & Akpan, 2022). The initiative also aims to restore ecosystems and livelihoods across the Sahel by addressing the social, economic, and environmental impacts of land degradation.

In Nigeria, the National Agency of the Great Green Wall (NAGGW) is mandated to advance the initiative's objectives. The agency has implemented an integrated approach intervention strategy aimed at strengthening rural livelihoods and improving resilience in degraded and climate-vulnerable states such as Gombe, Kebbi, and Sokoto. Pivotal to its mandate is ecological restoration, which focuses on restoring degraded landscapes through soil and water conservation, reforestation, and sustainable land management. These actions improve ecological conditions, such as soil fertility and water retention, which are crucial for agricultural productivity and income generation (Nkonya et al., 2026).

To mitigate the social and economic vulnerability of households affected in the frontline states of the Sahel in Nigeria, the NAGGW promotes multiple livelihoods by facilitating access to agricultural inputs, supporting smallholder enterprises, and promoting value addition in agroforestry and non-timber forest products (NTFP). These interventions aim to expand income opportunities beyond subsistence farming, to reduce dependency on climate-sensitive activities, and strengthen household livelihoods (de la O Campos et al., 2024). The agency also promotes institutional strengthening and community participation by supporting local development committees, planning processes, and collaborative networks that strengthen social capital and joint action. These social structures are crucial for sustaining intervention benefits and encouraging unified community action to climate hazards.

Previous studies have shown that prolonged disasters, whether natural, biological, or socio-political, can significantly disrupt livelihoods, strain community resources, and overwhelm local coping mechanisms. Audu & Adie (2018) reviewed the causes and consequences of desertification in northern Nigeria, arguing that climate variability, deforestation, overgrazing, bush burning, fuel wood extraction, and urbanisation contribute to the problem and highlight the need to plant climate-resistant trees to address livelihood gaps. Denton et al. (2015) examined climate resilience initiatives in the Sahel, highlighting the significance of strengthening livelihood resilience among vulnerable groups. Although their study underscored the significance of livelihood land degradation and community-resilient approaches, it did not specifically evaluate the GGWI's outcomes on the livelihood capitals of affected households in the frontline states. Kehinde (2025) analysed access to livelihood capitals and their impact on land allocation decisions among smallholder farmers in Nigeria. While the study examined this among 240 farmers using a multivariate probit regression, access to these capitals was influenced by several factors, including age, marital status, access to credit, associational membership, and primary education.

This study identified some gaps in previous studies. Available studies have generally addressed climate resilience among vulnerable groups, primarily using secondary data and review articles. The focus of this study is a major programme of the Nigerian government that aligns with regional governments' commitments, making the study's findings particularly important. This study provides insights into the effects of NAGGW interventions on households' physical, human, financial, social, and natural capital in three frontline states in Nigeria: Gombe, Kebbi, and Sokoto. Specifically, the study analysed two objectives, namely: 1) to determine the effect of the GGWI on the livelihood capital of the households; and 2) to compare the difference in the effect of the GGWI on the livelihood capital of beneficiaries in comparison to non-beneficiaries.

This comparison of the livelihood capital of beneficiaries and non-beneficiaries will help establish whether the observed changes are due to the interventions or to other factors beyond the agency's influence. This study is important because it provides valuable insights into academic literature on environmental sustainability. It highlights how institutional interventions can address livelihood challenges, especially for vulnerable households whose livelihood capital is threatened by climate change and environmental degradation. Also, given the sociodemographic and ecological variations across states in Nigeria, its focus on frontline states, and how the initiatives of the NAGGW influence their livelihood capital, this study highlights how social protection interventions can change the livelihood outcomes of those at the margins of the negative impacts of climate change.

2. Materials and Methods

2.1. Study Population, Sampling and Data Collection

This study was carried out in Nigeria, focusing on the frontline states along the Sahel. Eleven states in Nigeria lie within the Sahel ecological zone and are mostly affected by desertification, land degradation, climate variability, and livelihood vulnerability, namely: Adamawa, Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe, and Zamfara. Of these eleven states, three were purposively selected for the study: Gombe, Kebbi, and Sokoto. The choice of these states is because of their relatively high poverty rates (National Bureau of Statistics, 2022). A cross-sectional research design was used to collect data from households that had benefited from NAGGW interventions and from households that had not. The inclusion of non-beneficiaries in the study was to help establish whether the changes in the livelihood capital of the beneficiaries are influenced by the interventions of NAGGW. Table 1 shows the sample sizes for each state, reflecting the number of beneficiaries and non-beneficiaries selected. The rising

insecurity in the northern states at the time of data collection affected data collection among non-beneficiaries, particularly in Gombe state, where the prevalence of kidnapping and restricted mobility hindered the process, given that the non-beneficiaries were selected from communities that did not benefit from the interventions, with some of these communities prone to attacks, which restricted movement for data collection. While this introduces selection bias, it reflects the field-based realities of research in high-conflict areas of Nigeria. While equal sample sizes are often preferred in experimental research, unequal sample sizes do not invalidate a study. Oldfield (2016) noted that unequal sample sizes may result from practical considerations such as participant availability, study cost, and statistical power, and argued that unequal samples can still yield rigorous and reliable results and, in some cases, may even enhance statistical power. Hence, one way this study addressed potential selection bias stemming from unequal sample sizes is through its analytical approach. Regression analysis was used, which does not assume equal group sizes and treats beneficiary status as an explanatory variable. In addition, some socio-demographic characteristics were controlled for in the analysis to minimise potential selection bias arising from systematic differences between beneficiaries and non-beneficiaries (Steiner et al., 2010).

Table 1. Sample size.

Respondents	Gombe	Kebbi	Sokoto	Total
Beneficiaries	59	70	59	**188**
Non-beneficiaries	30	11	33	**74**
Total	**89**	**81**	**92**	**262**

Primary data were collected from respondents using structured questionnaires designed in line with the agency's interventions.

2.2. Measurement of Variables

This was operationalised in line with the sustainable livelihood framework, which identified five livelihood capitals: physical, human, financial, social, and natural capital (Ongachi & Belinder, 2025, Chambers & Conway, 1992). The variables measured under each of the livelihood capitals are outlined:

Physical capital: this was operationalised to measure households' access to power supply, boreholes, roads and ownership of mobile phones.

Human capital: this was operationalised to measure attainment of secondary education, possession of employable skills, household food security (household not requiring food assistance), household cash security (household not requiring cash assistance), household nutritional adequacy (household eats a balanced diet), access to healthcare facilities within the community,

Financial capital: this variable was operationalised to measure whether the household is economically active, the presence of a functional market in the community, access to bank savings and credit facilities in the community, access to a local savings and credit group, and access to land for economic activities

Social capital was measured by households' membership in community social groups, community participation, contributions to community welfare, contributions to community decision-making, and attendance at community meetings.

Natural capital: this measures access to land for farming/animal rearing, access to land with economic trees/forest resources and access to rivers/streams in the community.

To establish the reliability of the scale used for measuring the livelihood capital in this study, the indicators for each of the livelihood capital (physical, human, financial, social and natural) were subjected to a reliability analysis using Cronbach's Alpha. The analysis indicated high internal consistency across all the livelihood capitals. The result is shown in Table 2.

Table 2. Reliability Analysis of livelihood capitals.

Livelihood capital	Number of items	Cronbach's α	Reliability
Physical capital	4	0.86	Acceptable internal consistency
Human capital	7	0.91	Acceptable internal consistency
Financial capital	4	0.87	Acceptable internal consistency
Social capital	5	0.92	Acceptable internal consistency
Natural capital	3	0.75	Acceptable internal consistency

* reliability coefficient >0.70 is acceptable.

2.3. Data Analysis

The data was analysed using descriptive and inferential statistics. Mean differences were used to describe differences in the livelihood capital of beneficiaries and non-beneficiaries, while regression analysis provided deeper insights into the effects of

the NAGGW interventions on beneficiaries' livelihood capital.

The regression analysis was designed to estimate the association between programme participation and post-intervention livelihood capital outcomes, while controlling for respondents' socio-demographic characteristics. Separate regression models were estimated for each of the five livelihood capital dimensions: physical capital, human capital, financial capital, social capital, and natural capital. Each dependent variable was constructed as a composite index derived from the study's indicators, with internal consistency confirmed through reliability analysis (Table 2).

The general model of the regression is specified as:

$$LC_{is} = \beta_0 + \beta_1 \text{Beneficiary}_{is} + \beta_2 X_{is} + \beta_3 \text{State}_{is} + \varepsilon_{is} \quad (1)$$

where LC_{is} = livelihood capital outcome for respondent i in state s, Beneficiary_{is} = binary indicator (1 = beneficiary, 0 = non-beneficiary), X_{is} = socio-demographic control variables (age, sex, marital status, education, employment status), State_{is} = state dummy variables, β_0 is the intercept, β_1 to β_3 are parameters to be estimated, ϵ_{is} = error term.

Based on the variables analysed in the study, the estimated model becomes:

$$\begin{aligned} LC_i = {} & \beta_0 + \beta_1 \text{Beneficiary}_i + \beta_2 \text{Age}_i + \beta_3 \text{Sex}_i + \beta_4 \text{NeverMarried}_i + \beta_5 \text{Separated}_i + \beta_6 \text{Divorced}_i + \beta_7 \text{Widowed}_i + \beta_8 \text{Primary}_i \\ & + \beta_9 \text{Secondary}_i + \beta_{10} \text{Tertiary}_i + \beta_{11} \text{PublicEmp}_i + \beta_{12} \text{PrivateEmp}_i + \beta_{13} \text{SelfEmp}_i + \beta_{14} \text{Kebbi}_i + \beta_{15} \text{Sokoto}_i + \varepsilon_i \end{aligned} \quad (2)$$

The categorical explanatory variables were transformed into dummy variables before estimation.

For marital status, married respondents served as the reference category, and never married, separated, divorced, and widowed were included as dummy variables.

For educational attainment, no formal education was used as the reference category, while primary, secondary, and tertiary education were entered as dummy variables.

For employment status, unemployed respondents served as the omitted category, while public-sector employed, private-sector employed, and self-employed respondents were represented by dummy variables.

For state location, Gombe State was used as the reference category, while Kebbi and Sokoto were included as state dummies.

The regression models were estimated separately for each livelihood capital to identify whether the intervention had differential associations across the various dimensions of livelihoods. Because the dependent variables are continuous composite indices, OLS estimation was considered appropriate. The inclusion of socio-demographic controls and state dummy variables helped to reduce omitted-variable bias arising from observable differences between beneficiaries and non-beneficiaries, which is consistent with the broader regression literature on confounding adjustments in observational studies (Cinelli & Hazlett, 2020; Plümper & Troeger, 2019).

The regression analysis indicates that positive, statistically significant coefficients on the beneficiary variable indicate that respondents' participation in the NAGGW interventions was associated with higher livelihood capital scores relative to non-beneficiaries, after accounting for other covariates in the model. Although retrospective information on pre-intervention conditions was collected, only post-intervention livelihood capital indices were used in the regression models in order to minimize recall bias.

The Statistical Package for the Social Sciences (SPSS) was used for the analysis.

3. Results

3.1. Households' Sociodemographic Characteristics

Table 3 presents respondents' sociodemographic characteristics across three states. The results show that most respondents were male (64.5%), with a higher proportion in Sokoto (78.3%). Most respondents were young people, with Gombe State accounting for the highest proportion at 52.8%, representing those aged 30 years or younger. This was observed across the states, where most respondents were under 40 years, indicating a relatively youthful, energetic, and economically active population. Most respondents were married (64.5%), while 72.5% were self-employed, reflecting dependence on personal income. Educational attainment varied significantly across states, with Sokoto recording the highest percentage of respondents with no formal education (42.4%), indicating disparities in educational access within the study areas.

3.2. Effect of GGWI on Livelihood Capital

To understand the effect of the GGWI on livelihood capital, a regression analysis was conducted, focusing on post-intervention livelihood capital among beneficiaries and non-beneficiaries. Participation in the intervention was coded 1 for beneficiaries and 0 for non-beneficiaries. Some sociodemographic variables were used as control groups, including Gombe State, which served as the

Table 3. Percentage distribution of the sociodemographic characteristics of the respondents.

Characteristics	Factor	Gombe (n = 89)	Kebbi (n = 81)	Sokoto (n= 92)	Total (n = 262)
Sex	Male	59.6	54.3	78.3	64.5
	Female	39.3	38.3	19.6	32.1
	No response	1.1	7.4	2.2	3.4
Age	Less than 30	52.8	29.6	30.4	37.8
	30-39	44.9	40.1	34.8	40.1
	40-49	1.1	19.8	28.3	16.4
	50-59	1.2	3.7	6.5	3.8
	60-69	-	6.2	-	1.9
Marital status	Never married	21.3	23.5	18.5	21
	Married	58.4	60.5	73.9	64.5
	Separated	7.9	2.5	2.2	4.2
	Divorced	10.1	6.2	3.3	6.5
	Widowed	1.1	4.9	2.2	2.7
	No response	1.1	2.5	-	1.1
Employment status	Unemployed	9	29.6	5.4	14.1
	Public sector employed	1.1	3.7	13	6.1
	Private sector employed	6.7	2.5	3.3	4.2
	Self employed	80.9	56.8	78.3	72.5
	No response	2.2	7.4	-	3.1
Educational qualification	No formal education	5.6	27.2	42.4	25.2
	Primary school	6.7	21	20.7	16
	Secondary school	83.1	33.3	25	47.3
	Graduate	3.4	3.7	8.7	5.3
	No response	1.1	14.8	3.3	6.1

reference group for the states covered in the study. The results of the regression analysis are presented for each livelihood capital.

Table 4 presents the regression analysis for physical capital among respondents in the study locations. The results show that participation in the NAGGW interventions was positively and significantly associated with physical capital. Specifically, beneficiaries recorded significantly higher physical capital scores than non-beneficiaries (β=1.06, t=9.75, p<0.001), holding constant age, sex, marital status, employment status, education, and state of residence. This indicates that, net of other observed factors, beneficiaries had greater access to physical capital-related assets and services than non-beneficiaries in the post-intervention period. Among the control variables, none of the socio-demographic characteristics was statistically significant at the 5% level, as none showed a significant independent association with physical capital. In contrast, locational effects were substantial and statistically significant. Relative to Gombe State, respondents in Kebbi State had markedly higher physical capital scores (β=2.85, t=18.93, p<0.001), while respondents in Sokoto State also recorded significantly higher physical capital scores (β=1.00, t=6.53, p<0.001). The model explained a substantial proportion of the variation in physical capital (R^2=0.73), indicating that 73% of the observed change in beneficiaries' physical capital was due to NAGGW's interventions.

Table 4. Regression analysis of the effect of the interventions on the physical capital of respondents.

Variables	β	t	P-value
Benefitting individuals	1.06	9.75	<0.001*
Age	-0.01	-1.02	0.31
Sex	0.10	0.88	0.38
Married	0.22	1.56	0.12
Separated	0.41	1.45	0.15
Divorced	0.16	0.61	0.54
Widowed	0.44	1.30	0.20
Public sector employed	-0.16	-0.51	0.61
Private sector employed	-0.23	-0.78	0.44
Self-employed	0.17	0.99	0.33
Primary school	0.14	0.84	0.40
Secondary school	0.10	0.66	0.51
Tertiary education	-0.04	-0.12	0.90
Kebbi State	2.85	18.93	<0.001*
Sokoto State	1.00	6.53	<0.001*
Constant	-0.92	-2.92	0.004*
Observation	262		
R^2	0.73		
F	<0.001		

Table 5 presents the post-intervention regression estimates for human capital. The results show that beneficiary status is positively and significantly associated with human capital outcomes. Specifically, beneficiaries recorded significantly higher human capi-

tal scores than non-beneficiaries (β = 1.39, t = 6.55, p < 0.001), after controlling for age, sex, marital status, employment status, educational attainment, and state of residence. This indicates that, net of other observed factors, participation in the NAGGW intervention is associated with stronger human capital outcomes in the post-intervention period. The socio-demographic variables were not statistically significant at the 5% level, suggesting that differences in human capital were not primarily explained by individual demographic characteristics once programme participation and location were taken into account. With respect to location, respondents in Kebbi State had significantly higher human capital scores than those in Gombe State, the reference category (β = 3.92, t = 14.90, p < 0.001), while the coefficient for Sokoto State was not significant (β = 0.50, t = 1.85, p = 0.07). The model explained a substantial proportion of the variation in human capital (R^2 = 0.66), indicating that 66% of the observed changes in beneficiaries' human capital were due to the interventions.

Table 5. Regression analysis of the effect of the interventions on the human capital of respondents.

Variables	β	**t**	**P-value**
Benefitting individuals	1.39	6.55	<0.001*
Age	-0.01	-0.75	0.46
Sex	0.12	0.60	0.55
Married	-0.12	0.50	0.62
Separated	0.19	0.38	0.71
Divorced	0.07	0.15	0.88
Widowed	-0.44	-0.75	0.46
Public sector employed	0.31	0.54	0.59
Private sector employed	-0.61	-1.19	0.23
Self-employed	-0.04	-0.14	0.89
Primary school	0.39	1.33	0.18
Secondary school	0.21	0.76	0.45
Tertiary education	-0.31	-0.60	0.55
Kebbi State	3.92	14.90	<0.001
Sokoto State	0.50	1.85	0.07
Constant	-0.36	-0.66	0.51
Observation	262		
R^2	0.66		
F	<0.001		

Table 6 presents the post-intervention regression estimates for financial capital. The results show that beneficiary status is positively and significantly associated with financial capital outcomes. Specifically, beneficiaries recorded significantly higher financial capital scores than non-beneficiaries (β = 0.88, t = 6.58, p < 0.001), after controlling for age, sex, marital status, employment status, educational attainment, and state of residence. This indicates that, net of other observed factors, participation in the NAGGW intervention is associated with stronger financial capital outcomes in the post-intervention period. The socio-demographic variables were not statistically significant at the 5% level. With respect to location, respondents in Kebbi State had significantly higher financial capital scores than those in Gombe State, the reference category (β = 2.40, t = 14.48, p < 0.001), while respondents in Sokoto State also had significantly higher financial capital scores (β = 0.52, t = 3.10, p = 0.002). The model explained a substantial proportion of the variation in financial capital (R^2 = 0.62), accounting for 62% of the observed change in beneficiaries' financial capital.

Table 6. Regression analysis of the effect of the interventions on the financial capital of respondents.

Variables	β	**t**	**P-value**
Benefitting individuals	0.88	6.58	<0.001*
Age	-0.01	-0.711	0.48
Sex	0.01	0.06	0.95
Married	-0.17	-1.06	0.29
Separated	-0.19	-0.62	0.54
Divorced	-0.29	-1.05	0.29
Widowed	-0.67	-1.79	0.08
Public sector employed	0.66	1.86	0.06
Private sector employed	-0.11	-0.36	0.72
Self-employed	0.18	0.92	0.36
Primary school	0.01	0.06	0.96
Secondary school	-0.05	-0.31	0.76
Tertiary education	-0.23	-0.70	0.48
Kebbi State	2.40	14.48	<0.001*
Sokoto State	0.52	3.10	0.002*
Constant	-0.33	-0.94	0.35
Observation	262		
R^2	0.62		
F	<0.01		

Table 7 presents the post-intervention regression estimates for social capital. The results show that beneficiary status is positively and significantly associated with social capital outcomes. Specifically, beneficiaries recorded significantly higher social capital scores than non-beneficiaries (β = 1.25, t = 7.69, p < 0.001), after controlling for age, sex, marital status, employment status, educational attainment, and state of residence. This indicates that, net of other observed factors, participation in the NAGGW intervention is associated with stronger social capital outcomes in the post-intervention period. Most of the socio-demographic variables were not statistically significant at the 5% level, except for public sector employment (β = 1.29, t = 2.98, p = 0.03). With respect to location, respondents in Kebbi State had significantly higher social capital scores than those in Gombe State, the reference category (β = 3.19, t = 15.81, p < 0.001), while respondents in Sokoto State also had significantly higher social capital scores (β = 0.62, t = 3.00, p = 0.003). The model explained a substantial proportion of the variation in social capital (R^2 = 0.68), accounting for 68% of the observed changes in beneficiaries' social capital.

Table 7. Regression analysis of the effect of the interventions on the social capital of respondents.

Variables	B	t	P-value
Benefitting individuals	1.25	7.69	<0.001*
Age	-0.01	-1.31	0.19
Sex	-0.09	-0.60	0.55
Married	-0.11	-0.55	0.58
Separated	0.13	0.34	0.73
Divorced	0.02	0.07	0.94
Widowed	-0.24	-0.53	0.59
Public sector employed	1.29	2.98	0.003*
Private sector employed	-0.31	-0.79	0.43
Self-employed	-0.03	-0.11	0.91
Primary school	0.01	0.05	0.96
Secondary school	-0.04	-0.18	0.86
Tertiary education	-0.47	-1.18	0.24
Kebbi State	3.19	15.81	<0.001*
Sokoto State	0.62	3.00	0.003*
Constant	-0.21	-0.49	0.62
Observation	262		
R^2	0.68		
F	<0.001		

Table 8 presents the post-intervention regression estimates for natural capital. The results show that beneficiary status is positively and significantly associated with natural capital outcomes. Specifically, beneficiaries recorded significantly higher natural capital scores than non-beneficiaries (β = 0.40, t = 4.33, p <0.001), after controlling for age, sex, marital status, employment status, educational attainment, and state of residence. This indicates that, net of other observed factors, participation in the NAGGW intervention is associated with stronger natural-capital outcomes in the post-intervention period.

Most of the socio-demographic variables were not statistically significant at the 5% level, suggesting that differences in natural capital were not primarily explained by age, sex, marital status, or education once programme participation and location were considered. However, public sector employment was positively and significantly associated with natural capital (β = 0.80, t = 3.24, p = 0.001), indicating that respondents in public sector employment tended to record higher natural capital scores than the unemployed reference category. With respect to location, respondents in Kebbi State had significantly higher natural capital scores than those in Gombe State, the reference category (β = 1.45, t = 12.58, p <0.001), while the coefficient for Sokoto State was positive but not statistically significant at the 5% level (β = 0.19, t = 1.61, p = 0.11). The model explained a moderate proportion of the variation in natural capital (R^2 = 0.54), indicating that 52% of the observed changes in the natural capital of the respondents were due to the NAGGW interventions.

3.3. Difference in Livelihood Capital of Beneficiaries and Non-beneficiaries

A description of changes in the livelihood capitals of non-beneficiaries and beneficiaries is presented in Table 9, using mean differences. The observed mean differences in livelihood capital outcomes between the groups provided some insight into whether the changes were due to the interventions.

Table 9 revealed substantial differences in the pattern of change in livelihood capitals between beneficiaries and non-beneficiaries of the NAGGW intervention across the study area. Among non-beneficiaries, the mean scores for all five livelihood capitals declined sharply between the pre- and post-intervention periods. Physical capital decreased from 1.45 to 0.07, human capital from 1.73 to 0.18, financial capital from 1.38 to 0.07, social capital from 1.58 to 0.07, and natural capital from 0.88 to 0.07. This indicates a broad deterioration in livelihood conditions among households that did not benefit from the intervention.

For beneficiaries, the pattern was different. Physical capital increased slightly from 1.56 to 1.67, while human capital declined marginally from 2.64 to 2.39. Financial capital fell from 2.04 to 1.37, social capital declined from 1.98 to 1.84, and natural capital

Table 8. Regression analysis of the effect of the interventions on the natural capital of respondents.

Variables	β	t	P-value
Benefitting individuals	0.40	4.33	<0.001*
Age	-0.003	-0.58	0.56
Sex	-0.10	-1.23	0.22
Married	-0.08	-0.76	0.45
Separated	-0.16	-0.75	0.45
Divorced	-0.16	-0.81	0.42
Widowed	-0.16	-0.61	0.54
Public sector employed	0.80	3.24	0.001*
Private sector employed	0.13	0.59	0.56
Self-employed	0.33	2.44	0.12
Primary school	-0.03	-0.24	0.81
Secondary school	0.03	0.22	0.83
Tertiary education	-0.36	-1.57	0.12
Kebbi State	1.45	12.58	<0.001*
Sokoto State	0.19	1.61	0.11
Constant	-0.34	-1.34	0.18
Observation	262		
R^2	0.54		
F	<0.001*		

decreased from 1.55 to 0.71. Although not all livelihood capitals improved among beneficiaries, their post-intervention mean scores remained consistently higher than those of non-beneficiaries across all five dimensions. The finding suggests that beneficiaries maintained stronger livelihood asset positions than non-beneficiaries in the post-intervention period.

Table 9. Change in livelihood capital of beneficiaries and non-beneficiaries.

Livelihood capital	Non-beneficiaries (n = 74)		Beneficiaries (n = 188)	
	Before	After	Before	After
	Mean (stdv)		Mean (std)	
Physical capital	1.45 (±1.60)	0.07 (±0.42)	1.56 (±1.71)	1.67 (±1.50)
Human capital	1.73 (±2.38)	0.18 (±0.77)	2.64 (±2.69)	2.39 (±2.56)
Financial capital	1.38 (±1.57)	0.07 (±0.48)	2.04 (±1.43)	1.37 (±1.53)
Social capital	1.58 (±2.04)	0.07 (±0.58)	1.98 (2.18)	1.84 (±2.00)
Natural capital	0.88 (±0.07)	0.07 (±0.38)	1.55 (±1.04)	0.71 (±0.99)

4. Discussion

The dominance of younger respondents indicates potential for economic growth since they represent the economically active population. However, this may also reflect increased vulnerability, as this population group in Nigeria rarely has the requisite capital to mitigate the impact of climate change on their livelihoods. Also, with most indicating self-employment, this underscores the potential success of the interventions in creating economic opportunities for the respondents, given that most depend on income-generating activities, such as farming and small-scale trading, for their livelihoods. However, while self-employment offers flexibility and autonomy, it can expose households to irregular income, particularly in climate-sensitive sectors such as agriculture. The relatively high proportion of respondents without formal education, particularly in Sokoto, may limit access to information, hinder technology adoption, and constrain access to other livelihood opportunities that can enhance their livelihood capital, thereby constraining the capacity to adopt climate adaptation strategies. These findings align with (Ro & Lee, 2026), stressing that understanding the effects of climatic disasters on household livelihoods is essential for developing context-specific adaptive strategies. Previous studies also indicate that self-employment enhances autonomy, job satisfaction, and physical and mental well-being (Binder & Coad, 2016; Nikolova, 2019).

The regression analysis of physical capital indicates that the NAGGW intervention is strongly associated with improved physical capital outcomes among beneficiary households. The positive, statistically significant coefficient for beneficiary status suggests that the intervention meaningfully strengthened beneficiaries' access to infrastructure and productive assets, including water sources, electricity-related facilities, communication tools, and other material resources that support livelihood activities. In practical terms, this implies that participation in the intervention enhanced the asset base needed for production, mobility, communication, and household welfare.

The results further imply that the intervention was particularly important for differentiating the physical capital conditions of beneficiaries from those of non-beneficiaries. Beneficiaries appear to have been better positioned to retain or improve access to

physical livelihood assets, whereas non-beneficiaries remained relatively disadvantaged. This suggests that, in the study locations, programme participation may have served both an asset-building and protective function by helping beneficiary households avoid the more limited physical capital conditions observed among non-beneficiaries. The finding is in line with the study of Tadesse & Gebremedhin Zeleke (2022), who analysed the impact of productive safety net programme (PSNP) on the food security and asset accumulation of rural households in Ethiopia and found that the programme enhanced the nutritional daily intake and annual income of participating households relative to non-participating households.

The significant state effects also suggest that the intervention's influence was shaped by local context. The substantially higher coefficients for Kebbi and Sokoto indicate that physical capital outcomes were not determined by programme participation alone, but also by locational conditions such as pre-existing infrastructure, access to public services, and complementary state-level development efforts. This means that while the intervention was beneficial, its outcomes were likely amplified or constrained by the broader physical and institutional environment in each study location.

For beneficiaries, the implication of the finding is that the intervention improved their capacity to engage in livelihood activities through better access to enabling infrastructure and productive assets. Stronger physical capital can reduce transaction costs, improve market access, facilitate communication, and enhance resilience in rural livelihoods. For non-beneficiaries, however, the findings imply continued vulnerability stemming from weaker physical capital endowments. Their relatively lower levels of physical capital suggest that exclusion from the intervention may have limited their ability to access the basic material conditions necessary for improving or sustaining livelihoods. Recent empirical evidence reinforces this finding, as studies by Fuseini (2024) and Hartwig & Nguyen (2023) show that infrastructure and connectivity enhance market access, communication and livelihood resilience.

For sustained and equitable impact, future implementation should be accompanied by complementary investments in rural infrastructure and service delivery, especially in areas where baseline physical capital deficits remain high. This would help ensure that both current and potential beneficiaries are better able to translate intervention support into durable livelihood gains.

The positive, statistically significant coefficient for human capital in beneficiary status indicates that the NAGGW intervention strengthened participating households' human capital. In substantive terms, this means that beneficiaries were better positioned than non-beneficiaries across key human capital dimensions, including skills acquisition, educational attainment, food security, cash security, nutritional well-being, and access to healthcare-related services. The finding implies that the intervention was associated not only with livelihood support in a narrow economic sense, but also with improvements in the capabilities and welfare conditions that enable households to sustain livelihoods over time. For beneficiaries, the results suggest enhanced capacity to cope with livelihood challenges, supported by stronger foundations in knowledge, health, and welfare. For non-beneficiaries, however, the comparatively lower human capital outcomes imply continued vulnerability, including limited skills, weaker food and cash security, and reduced access to basic human development opportunities.

The strong locational effect observed for Kebbi State further indicates that human-capital outcomes were shaped by contextual differences across the study locations, including variation in service availability, programme delivery conditions, and broader socio-economic environments. The variations observed across contexts underscore the essential nature of the situation-specific programme design, adaptive frameworks, and continuous monitoring and evaluation to improve effectiveness in livelihood developments, especially for marginalised settings (Kazanskaia, 2025). From a broader perspective, the influence of human capital on beneficiaries' livelihoods suggests that the successful implementation of the NAGGW intervention in Nigeria can extend beyond environmental restoration to meaningful improvements in human well-being. However, it is important to sustain and equalise such gains across locations through complementary investments in education, community health services, nutrition support, and livelihood skills development.

The positive, statistically significant coefficient for financial capital in beneficiary status indicates that the NAGGW intervention strengthened participating households' financial capital. In substantive terms, this means that beneficiaries were better positioned than non-beneficiaries in key financial-capital dimensions, including economic activity, access to markets, savings and credit opportunities, and access to productive resources that support income generation. The finding implies that the intervention was associated with improved economic capacity and greater potential for livelihood diversification among beneficiaries. Studies by Ojo et al. (2024) and (Bamidele, 2024) show that livelihood diversification strengthens rural households' income, food security, and market participation, reinforcing the intervention's role in improving beneficiaries' economic capacity

For beneficiaries, the result suggests a stronger ability to mobilise resources, participate in local markets, and access financial support mechanisms that can enhance household resilience and productivity. For non-beneficiaries, however, the comparatively lower financial capital outcomes imply continued vulnerability, including weaker market integration, reduced access to credit and savings opportunities, and more limited capacity to finance livelihood activities. The strong locational effect observed for Kebbi State, and the significant positive effect for Sokoto State, further indicate that financial capital outcomes were shaped by contextual differences across the study locations, including variation in market functionality, financial service availability, programme delivery conditions, and broader economic opportunities. The extent to which the improvements were observed in the livelihood capital outcomes varies, even though the programme can potentially address these livelihood capitals, as observed by previous

studies (Nkonya et al., 2016; de la O Campos et al., 2024). The findings also underline the significance of capital endowment and financial strategies in sustaining livelihood benefits, as households with larger initial assets are better positioned to benefit from interventions (Bokhari, 2022).

Taken as a whole, the findings imply that successful implementation of the NAGGW intervention in Nigeria can extend beyond environmental restoration to measurable improvements in financial inclusion and local economic participation. However, sustaining and broadening such gains across locations may require complementary investments in rural markets, community savings structures, access to credit, and support for productive assets.

The positive, statistically significant coefficient for social capital and beneficiary status indicates that the NAGGW intervention strengthened participating households' social capital. In substantive terms, this means that beneficiaries were better positioned than non-beneficiaries across key social capital dimensions, including group membership, participation in community activities, contributions to collective welfare, involvement in decision-making, and attendance at community meetings. The finding implies that the intervention was associated not only with material livelihood support but also with stronger social connectedness, collective action, and local institutional participation. For beneficiaries, the result suggests improved integration into community structures that can enhance access to information, mutual support, trust, and cooperation for livelihood advancement. For non-beneficiaries, however, the comparatively lower social capital outcomes imply weaker participation in collective processes and reduced access to the community-based networks that often facilitate resilience and resource mobilisation. As pointed out in the study by da Silva Cavalcante et al. (2022), human and social capital led to improvements in livelihood outcomes among family farmers, underscoring the role of integrating community structures to enhance cooperation, information access, and livelihood improvements in rural communities.

The positive and significant state effects for Kebbi and Sokoto further indicate that social capital outcomes were shaped by locational context, including differences in community organisation, programme delivery conditions, and the strength of local institutions across the study areas. From a general angle, the findings imply that successful implementation of the NAGGW intervention in Nigeria can generate benefits beyond environmental restoration by strengthening the social foundations of livelihoods. However, sustaining and broadening these gains may require continued support for inclusive community organisations, participatory governance structures, and locally embedded mechanisms that encourage collective responsibility and cooperation.

The positive, statistically significant coefficient for natural capital and beneficiary status indicates that the NAGGW intervention strengthened participating households' natural capital. In substantive terms, this means that beneficiaries were better positioned than non-beneficiaries to access land for farming and livestock activities, economically useful trees and forest resources, and water-related natural resources such as rivers and streams. The finding implies that the intervention was associated with improved access to or protection of the natural-resource base that supports rural livelihoods in the study locations.

For beneficiaries, the result suggests improved capacity to sustain agricultural and natural-resource-based livelihood activities through stronger access to key environmental assets. This is especially important in dryland and ecologically vulnerable areas where livelihoods depend heavily on land, vegetation, and water availability. For non-beneficiaries, however, the comparatively lower natural capital outcomes imply continued vulnerability arising from weaker access to productive natural resources and reduced environmental support for livelihood activities. This suggests that exclusion from the intervention may leave households less able to cope with environmental stress and livelihood insecurity.

The strong positive locational effect observed for Kebbi State further indicates that natural capital outcomes were shaped not only by programme participation, but also by contextual differences across the study locations. These may include variations in land availability, ecological conditions, resource endowment, local tenure arrangements, and programme implementation context. The absence of a statistically significant effect in Sokoto State suggests that the natural capital advantages observed there were not sufficiently different from those in Gombe, even after controlling for other factors.

The analysis of natural capital findings implies that the successful implementation of the NAGGW intervention in Nigeria can strengthen the environmental resource base for rural livelihoods, particularly among participating households. However, sustaining and broadening such gains may require complementary efforts in land restoration, equitable access to natural resources, community-based resource governance, and protection of water and forest assets. In this regard, the intervention appears to support not only livelihood improvement, but also the ecological foundations upon which long-term livelihood resilience depends.

The analysis of differences in the livelihood capital of non-beneficiaries and beneficiaries also revealed some insightful patterns. The observed mean differences between beneficiaries and non-beneficiaries suggest that the NAGGW interventions contributed meaningfully to the protection and relative strengthening of livelihood assets among participating households. While the interventions did not produce uniform positive change across all capital dimensions, the comparatively better outcomes recorded for beneficiaries indicate that they served an important buffering function against livelihood decline. This is particularly important in vulnerable rural contexts where households are exposed to economic instability, environmental stress, and limited access to productive opportunities, particularly in northern Nigeria, where these rural households are vulnerable to climate change impacts and environmental degradation.

The slight increase in physical capital among beneficiaries may reflect the direct effect of programme support on access to productive assets, infrastructure, or material resources needed to sustain livelihoods. By contrast, declines in human, financial, social, and natural capital among beneficiaries suggest that these dimensions may be influenced by broader structural conditions that cannot be fully addressed by a single intervention, since the beneficiaries participated in only one intervention at a given time, even though several interventions were implemented by the agency. Nonetheless, the fact that beneficiary households remained considerably better off than non-beneficiaries implies that the programme helped reduce the severity of livelihood erosion. Fuseini (2024) found that providing infrastructure to rural households significantly enhanced beneficiaries' livelihoods, even though women's livelihoods are better enhanced by social infrastructure and men's by physical infrastructure. It is, however, important to note that when physical capital is not significant, this is likely due to the long-term nature of infrastructural development, which requires larger investments and longer implementation periods and can erode developmental opportunities (Doumbia, 2018). Similarly, in their study, da Silva Cavalcante et al. (2022) found that human and social capital are major contributors to improving the livelihoods of family farmers and can lead to increased commercialization of agriculture in rural communities.

This empirical evidence underscores the need to address systemic gaps in access to livelihood capitals, given their direct and significant relevance to livelihood outcomes, particularly for rural households that depend primarily on agriculture. For programme implementation in Nigeria, these findings imply that the NAGGW interventions can potentially improve livelihood outcomes through cushioning households against worsening deprivations due to environmental and climate impacts. However, the mixed pattern across livelihood capitals also indicates that successful implementation requires a more integrated strategy. To achieve stronger and more balanced outcomes, intervention delivery may need to be complemented by measures that promote income diversification, strengthen community networks, improve access to education and skills, expand financial inclusion, and enhance natural resource management.

The findings further imply that non-beneficiaries remain significantly more vulnerable to livelihood deterioration. Their consistently low post-intervention capital scores highlight the risks of exclusion from support programmes and underscore the importance of expanding coverage to similarly vulnerable households. In this regard, the intervention's effectiveness is reflected not only in the gains made by beneficiaries but also in the clear contrast between supported and unsupported groups.

5. Conclusion

This study shows that participation in the National Agency of the Great Green Wall (NAGGW) interventions is positively associated with improved livelihood outcomes across all five livelihood capitals: physical, human, financial, social, and natural. Regression results indicate that beneficiaries consistently recorded significantly higher capital levels than non-beneficiaries, even after controlling for socio-demographic factors and state-level differences. This suggests that the interventions have strengthened household assets, capabilities, resilience, and livelihood opportunities in the study locations. Descriptive findings support this pattern, showing that non-beneficiaries experienced sharper declines across livelihood capitals, while beneficiaries maintained relatively stronger positions. The results also reveal the importance of location, with Kebbi State, and in some cases Sokoto State, performing better than Gombe State, implying that infrastructure, market access, institutions, and ecological conditions of the states where the interventions were carried out shape programme outcomes. The study shows that the intervention has served as an important livelihood support mechanism in northern Nigeria by improving access to productive assets, enhancing human well-being, strengthening financial and social inclusion, and supporting the natural resource base. However, variations across capitals and locations indicate the need for a more integrated and context-sensitive implementation approach to sustain long-term resilience and address the vulnerability of non-beneficiaries. The study recommends greater investment in rural infrastructure and productive assets, such as roads, water, electricity, and communication facilities, to improve physical capital. To strengthen human capital, NAGGW should expand its livelihood skills training, adult education, nutrition support, health outreach, and household welfare services programmes for wider impacts. Financial capital can be improved through expanded access to community savings schemes, revolving funds, credit facilities, market linkages, and income-generating support. To build social capital, greater support should be given to inclusive community institutions, producer groups, cooperatives, and participatory decision-making structures to deepen trust, collective action, and information sharing. To enhance natural capital, the programme should further integrate sustainable land management, equitable resource access, community-based natural-resource governance, tree restoration, and water resource protection. Together, these measures would help deepen programme gains, reduce persistent vulnerabilities, and promote more balanced and durable livelihood resilience.

Author Contributions

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Declarations

Conflicts of Interest: The authors declare no conflict of interest.

Institutional/Ethical Approval: The study was conducted in accordance with standard ethical principles for social science research. While no ethical approval was obtained, the study was conducted under the written permission of the National Agency for the Great Green Wall, which provided field support to beneficiaries of their interventions, and with the consent of non-beneficiaries of the study. Participation in the survey was voluntary, and respondents were informed of the study's purpose. No personal identifying information was collected during the study to maintain anonymity.

Data Availability/Sharing: The datasets used and analysed during the current study will be made available from the corresponding author upon a reasonable request.

Supplementary Information Availability: Not applicable.

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