eISSN 2544-0659
ISSN 2081-6960 (zawieszony)

Zeszyty Naukowe
Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie

Scientific Journal
Warsaw University of Life Sciences – SGGW

PROBLEMY ROLNICTWA ŚWIATOWEGO

PROBLEMS OF WORLD AGRICULTURE

Vol. 23 (XXXVIII) 2023
No. 3

eISSN 2544-0659
ISSN 2081-6960 (zawieszony)

Zeszyty Naukowe
Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie

Scientific Journal
Warsaw University of Life Sciences – SGGW

PROBLEMY ROLNICTWA ŚWIATOWEGO

PROBLEMS OF WORLD AGRICULTURE

Vol. 23 (XXXVIII) No. 3

Warsaw University of Life Sciences Press
Warsaw 2023

Lista recenzentów jest publikowana w ostatnim zeszycie w roku oraz na stronie internetowej czasopisma. / The list of reviewers is published in the last issue of the year and on the journal's website.
Wersja elektroniczna jest wersją pierwotną. / The primary version of the journal is the on-line version.

Indeksacja w bazach danych / Indexed within:
ERIH PLUS, Index Copernicus, Baza Agro, BazEkon, System Informacji o Gospodarce Żywnościowej, Arianta Naukowe i Branżowe Polskie Czasopisma Elektroniczne, AgEcon search, CEJSH, PBN, Biblioteka Narodowa, Google Scholar, DOAJ, Crossref, EBSCO.

prs.wne.sggw.pl

e-ISSN 2544-0659, ISSN 2081-6960 (zawieszony)

Wydawnictwo SGGW / Warsaw University of Life Sciences Press
www.wydawnictwosggw.pl

SPIS TREŚCI

Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie
Problemy Rolnictwa Światowego tom 23(XXXVIII), zeszyt 3, 2023: 4-19
DOI: 10.22630/PRS.2023.23.3.9

Antoni Faber[1], Zuzanna Jarosz[2]
Instytut Uprawy Nawożenia i Gleboznawstwa – Państwowy Instytut Badawczy

Zmiany i możliwości rozwoju biogospodarki w Polsce na tle Unii Europejskiej

Changes and Opportunities for the Development of Bioeconomy in Poland against the Background of the European Union

Synopsis. Celem opracowania było określenie zmian i możliwości rozwoju biogospodarki w Polsce. W badaniach wykorzystano wskaźnik wartości dodanej, liczbę osób zatrudnionych oraz produktywność pracy dla poszczególnych sektorów stanowiących komponent biogospodarki. Przeprowadzona analiza struktury oraz kształtowania się dynamiki zmian wskaźników w latach 2008-2019 pozwoliła wskazać potencjał rozwoju biogospodarki w Polsce. Badane wskaźniki przedstawiono na tle całej UE. Z przeprowadzonych analiz wynika, że biogospodarka stanowi obiecującą koncepcję rozwoju sektorów wytwarzających i wykorzystujących biosurowce. Istotnym elementem rozwoju biogospodarki jest wsparcie badań i innowacji. Konsekwentnie realizowana polityka wspierająca biogospodarkę oraz środki na rozwój biotechnologii umożliwą produkcję bioproduktów o większej wartości dodanej, co tym samym wpłynie na poprawę jakości życia ludzi zatrudnionych w całej biogospodarce i jej sektorach.

Słowa kluczowe: biogospodarka, wartość dodana, zatrudnienie, produktywność pracy

Abstract. The aim of the study was to determine the changes and opportunities for the development of bioeconomy in Poland. The study used the value added indicator, the number of people employed and labor productivity for individual sectors that are a component of the bioeconomy. The conducted analysis of the structure and dynamics of changes in indicators in 2008-2019 allowed to determine the potential for the development of bioeconomy in Poland. The examined indicators are presented against the background of the entire EU. The conducted analyses show that the bioeconomy is a promising concept for the development of sectors producing and using bio-based raw materials. An important element of the development of the bioeconomy is the support for research and innovation. Consistently implemented policy supporting the bioeconomy and funds for the development of biotechnology will enable the production of bioproducts with greater added value, and thus will improve the lives of people employed in the entire bioeconomy and its sectors.

Key words: bioeconomy, added value, employment, labor productivity

JEL Classification: O13, Q15, Q56, Q57

[1] prof. dr hab., Zakład Biogospodarki i Analiz Systemowych IUNG-PIB, ul. Czartoryskich 8, 24-100 Puławy, e-mail: faber@iung.pulawy.pl; https://orcid.org/0000-0002-3055-1968
[2] dr, Zakład Biogospodarki i Analiz Systemowych IUNG-PIB, ul. Czartoryskich 8, 24-100 Puławy, e-mail: zjarosz@iung.pulawy.pl; https://orcid.org/0000-0002-3428-5804
Prace wykonano w ramach dotacji celowej nr 3 IUNG-PIB 2023 „Analiza potencjału podaży biomasy na poziomie krajowym i regionalnym”.

Wprowadzenie

Biogospodarka jako koncepcja, planowanie strategiczne i praktyka gospodarcza zaistniała szerzej w przestrzeni politycznej, naukowej i gospodarczej po ogłoszeniu przez Komisję Europejską strategii „Innowacje na rzecz zrównoważonego wzrostu: biogospodarka dla Europy" (EC, 2012). Strategia była odpowiedzią na wyzwania społeczne związane z koniecznością realizacji pięciu celów: bezpieczeństwa żywnościowego, zrównoważonego gospodarowania zasobami naturalnymi, ograniczenia uzależnienia od nieodnawialnych zasobów, mitygacji i adaptacji do zmian klimatu, wzrostu zatrudnienia oraz konkurencyjności unijnej gospodarki. W dokumencie podkreślono, że rozwój biogospodarki wymaga wprowadzenia szerokiego zakresu polityk skutecznie działających na poziomach: globalnym, UE, krajów członkowskich oraz regionów. Jednocześnie strategia wzywała do konstruktywnego dialogu na temat znaczenia dla biogospodarki postępu naukowego i sposobów politycznego wsparcia na poziomie UE i krajów członkowskich. Przyjęty w tym dokumencie plan strategicznych działań na rzecz rozwoju biogospodarki w UE obejmował inwestycje w badania, innowacje i umiejętności, zwiększenie interakcji polityk i zaangażowania zainteresowanych stron oraz wzmacnianie rynków i konkurencyjności. W 2017 r. dokonano przeglądu funkcjonowania strategii z 2012 r. stwierdzając między innymi, że: inwestycje w rozwój i innowacje przynoszą dobre rezultaty, cele przyjęte w strategii są ciągle aktualne, znaczenie biogospodarki rośnie, zmieniające się uwarunkowania wymagają silniejszego zogniskowania działań na przyjętych przez ONZ Celach Zrównoważonego Rozwoju (SDGs), politykach przemysłowych, gospodarce o obiegu zamkniętym oraz rozwoju wsi (EC, 2017). Na podstawie wyników dokonanego przeglądu strategia unijnej biogospodarki została znowelizowana w 2018 r. (EC, 2018). Opracowana nowa wersja strategii pt. „Zrównoważona biogospodarka dla Europy: wzmacnianie więzi pomiędzy gospodarką, społeczeństwem i środowiskiem" stanowi, że sercem europejskiej biogospodarki ma być jej zrównoważenie i obieg zamknięty. Podstawowe cele przed nią stawiane uległy niewielkiej korekcie: zapewnienie bezpieczeństwa żywnościowego i bezpieczeństwa odżywiania, zrównoważone gospodarowanie zasobami naturalnymi, zmniejszenie zależności od nieodnawialnych i niezrównoważonych zasobów pozyskiwanych w UE lub poza jej obszarem, mitygacja i adaptacja do zmian klimatu, wzmocnienie konkurencyjności gospodarki i tworzenie nowych miejsc pracy. Również w przyjętej strategii Europejskiego Zielonego Ładu potwierdzono kontynuację działań na rzecz realizacji przedstawionych celów (Komisja Europejska, 2019).

Konkurencja o kurczące się zasoby naturalne zapoczątkowała transformację gospodarczą zmierzającą do optymalnego wykorzystania zasobów odnawialnych oraz do zrównoważonego rozwoju systemów produkcji i przetwórstwa żywności w celu osiągnięcia większej gamy produktów przy jednoczesnym wykorzystaniu mniejszej ilości zasobów niezbędnych do ich produkcji z uwzględnieniem zmniejszenia negatywnego wpływu na środowisko naturalne (Gołębiewski, 2013). W literaturze podkreśla się, że prawidłowy rozwój biogospodarki jest możliwy wtedy, gdy wszystkie trzy wymiary (ekonomiczny, ekologiczny, społeczny) zrównoważonego rozwoju są w nim uwzględnione od samego początku transformacji gospodarczej (D'Adamo i in., 2020). Informacje na temat stanu oraz korzyści i trudności związanych z rozwojem biogospodarki pozwalają decydentom podejmować stosowne inicjatywy i działania zmierzające do dalszego rozwoju.

Celem opracowania było określenie zmian i możliwości rozwoju biogospodarki w Polsce. W przeglądzie literatury zaprezentowano definicję i znaczenie biogospodarki. Następnie przedstawiono charakterystykę metody badawczej wraz ze źródłem danych oraz analizę uzyskanych wyników, co pozwoliło wskazać zarówno zmiany, jak i potencjał rozwoju biogospodarki w Polsce. Badane wskaźniki przedstawiono na tle całej UE.

Przegląd literatury

Na przestrzeni lat idea biogospodarki była różnie definiowana. Pewną prawidłowością przy tworzeniu nowych definicji jest przechodzenie od ujęcia prostego do bardziej rozbudowanego oraz dostosowanie definicji do warunków krajowych lub potrzeb wykonywanej analizy. Jednoznaczne zdefiniowanie biogospodarki jest trudne ze względu na zakres oddziaływania. Według Czernyszewicz (2016) rozwój biogospodarki ma bezpośredni wpływ na wiele obszarów gospodarki, takich jak: bezpieczeństwo żywnościowe, zasoby naturalne, zmiany klimatu, rozwój ekonomiczno-społeczny, bezpieczeństwo energetyczne, zrównoważona produkcja i zdrowie publiczne. Zaznacza jednocześnie, że między wskazanymi obszarami a biogospodarką występuje sprzężenie zwrotne. Przeglądu definicji dokonali Maciejczak i Hofreiter (2013) wskazując, że poszczególne definicje akcentują różne interpretacje i kierunki koncepcji rozwojowych. Kompleksową definicję zaproponowała Komisja Europejska. Zaakcentowano w niej znaczenie zrównoważonej produkcji, interdyscyplinarnego charakteru biogospodarki oraz jej relacji wobec ekosystemu: „Biogospodarka obejmuje wszystkie sektory, opierające się na zasobach biologicznych – zwierzętach, roślinach, mikroorganizmach i wywodzącej się od nich biomasie, włączając w to odpady organiczne – ich funkcje i zasady. Obejmuje i łączy: lądowe i wodne ekosystemy i usługi, które te gwarantują; wszystkie sektory produkcji pierwotnej, które wykorzystują i tworzą zasoby biologiczne (rolnictwo, leśnictwo, rybactwo i akwakulturę); i wszystkie sektory gospodarcze, które wykorzystują zasoby biologiczne i przetwarzają je w żywność, pasze, produkty bazujące na biomasach, energię i usługi. Aby europejska biogospodarka funkcjonowała prawidłowo, winna opierać się na zrównoważonym rozwoju i obiegu zamkniętym. Będzie to stymulować odnowę przemysłu, modernizację systemów produkcji podstawowej i ochronę środowiska oraz przyczyni się do zwiększenia różnorodności biologicznej" (EC, 2018).

W ostatnich latach idei biogospodarki poświęca się coraz więcej uwagi. Biogospodarka jest traktowana jako koncepcja analityczno-poznawcza w ekonomii, wyrosła z potrzeb nauki i praktyki, która ułatwia naukowcom proces badania, a praktykom daje możliwość poznania zakresu, istoty oraz charakteru relacji zachodzących między różnymi elementami składowymi. Drugie ujęcie pokazuje, że biogospodarka to także prężnie rozwijający się obszar współczesnej gospodarki wykorzystującej w procesach gospodarczych zasoby biologiczne (Adamowicz, 2020). Idea biogospodarki polega na zastosowaniu strategicznej koncepcji zrównoważonego rozwoju, czyli sposobu realizacji dotychchzasowych celów gospodarczych przy jednoczesnym zminimalizowaniu wykorzystania zasobów naturalnych i negatywnego wpływu na środowisko dzięki nowym rozwiązaniom technologicznym. Oczekuje się więc, że zrównoważona i o obiegu zamkniętym biogospodarka poprzez ograniczenie wykorzystania zasobów nieodnawialnych odegra istotną rolę w transformacji systemu ekonomicznego (Brenne, 2022; Holden, 2022), a przekształcanie odnawialnych zasobów bologicznych w żywność, paliwo, chemikalia itp. przyniesie wzrost gospodarczy i korzyści środowiskowe (Devaney i Henchion, 2018). Również Gralak (2021) podkreśla, że wykorzystanie odnawialnych surowców biologicznych oraz efektywne gospodarowanie zasobami przyrodniczymi i energią ma istotne znaczenie dla przyszłego rozwoju gospodarki i przedsiębiorstw. Zdaniem Pink i Wojnarowskiej (2020) biogospodarka stanowi podstawę interdyscyplinarnego podejścia do rozwoju gospodarczego, łącząc ze sobą badania naukowe i know-how w dziedzinie biotechnologii z realnymi procesami gospodarczymi.

Na podstawie literatury dotyczącej biogospodarki można zaobserwować dwa główne podejścia do jej koncepcji. Z jednej strony biogospodarka nastawiona jest głównie na rozwój biotechnologii, kładąc nacisk na technologiczne lub produkcyjne aspekty biogospodarki (Pellis i in. 2018; Scheiterle i in., 2018). Z drugiej zaś zwrócono uwagę, że podejście zorientowane na biotechnologię nie wystarcza dla realizacji strategii biogospodarki na rzecz zrównoważonego rozwoju (Gołembiewski, 2015; Koukios i in., 2018). Autorzy (Scarlat i in., 2015; Bruckner i in., 2019; Liobikiene i in., 2019) podkreślają, że podstawową zasadą zrównoważonej biogospodarki jest zrównoważone wykorzystanie biomasy. Ponadto oceniając potencjał odnawialnych zasobów biologicznych należy zwrócić uwagę na nieprzekraczanie progów ekologicznych rozwoju biogospodarki (Faber i Jarosz, 2023; Liobikiene i in., 2019).

Biogospodarka jest umiejscowiona wysoko w politycznej agendzie zarówno w UE, jak również w wielu krajach członkowskich, co znajduje odzwierciedlenie w tworzonych strategiach rozwoju. Wiele państw opracowało strategie rozwoju biogospodarki zmierzające do uruchomienia niewykorzystanego potencjału – wzrostu ilości i jakości produktów, zwiększenia zatrudnienia (Austria, Finlandia, Francja, Hiszpania, Holandia, Irlandia, Niemcy, Łotwa, Portugalia, Włochy). W innych krajach są one aktualnie przygotowywane (Czechy, Chorwacja, Litwa, Polska, Słowacja, Węgry). Siedem krajów włączonych zostało do makroregionalnych (Bułgaria, Dania, Estonia, Rumunia, Słowenia, Szwecja) lub subnarodowych polityk dotyczących biogospodarki (Belgia). Natomiast w krajach takich jak: Cypr, Grecja, Luksenburg i Malta obowiązują inne strategie, które mają powiązania z biogospodarką (Lutzeyer, 2019; Brenne, 2022). Polska nie dysponuje jeszcze strategią biogospodarki, która jest na etapie konstruowania, a zagadnienia biogospodarki pojawiają się w różnych dokumentach strategicznych.

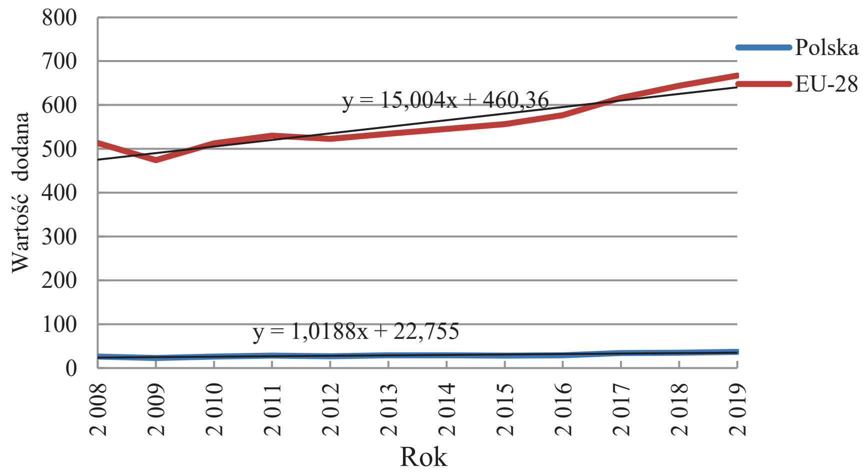
Nie jest łatwo przedstawić znaczenie biogospodarki w strukturze polskiej gospodarki, ponieważ obejmuje ona różnorodne sekcje i działy gospodarki narodowej połączone łańcuchem tworzenia wartości. Łańcuchy wartości w biogospodarce rozpoczynają się w sektorach produkcji pierwotnej (rolnictwo, leśnictwo, rybołówstwo i akwakultura) i ciągną się przez przetwórstwo żywności (przemysł spożywczy), pasz (przemysł paszowy), włókien i innych materiałów (przemysł tekstylny, drzewny, papierniczy, chemiczny) oraz sektor energetyczny bazujący na odnawialnych źródłach energii. Dzięki zastosowaniu różnorodnych procesów biomasa ulega transformacji na bardziej wartościowe produkty (Gołębiewski, 2013). Rozwój badań, opracowanie strategii oraz wdrażanie biogospodarki może być ważnym czynnikiem podnoszenia konkurencyjności naszego kraju.

Dane i metody

Opracowanie wskaźników do monitorowania i oceny rozwoju biogospodarki jest przedmiotem szerokiego zainteresowania (FAO, 2018; Jander i in. 2020; Ronzon i M'Barek, 2018). Również Komisja Europejska pracuje nad zidentyfikowaniem ram monitorowania biogospodarki (EC JRC, 2018). Wśród wielu proponowanych miar za istotne uznano te wskaźniki, które reprezentują wkład biogospodarki w tworzenie nowych miejsc pracy oraz dobro społeczeństwa. W analizie zastosowano wskaźnik wartości dodanej (WD) i liczbę osób zatrudnionych dla sektorów stanowiących komponent biogospodarki. To najczęściej wykorzystywane wskaźniki do monitorowania biogospodarki i pomiaru jej wielkości (Gołębiewski, 2020; Kuosmanen i in., 2020). Z bazy danych opracowanej w JRC EC (Tamošiūnas i in., 2022) pozyskano dane dotyczące wartości dodanej i zatrudnienia dla głównych sektorów biogospodarki. Analizę uzupełniono o wskaźnik produktywności pracy (PP). Do oceny produktywności pracy na poziomie sektorowym zastosowano wskaźnik o formule: produktywność pracy jest ilorazem wartości dodanej i wielkości zatrudnienia (Szewc-Rogalska, 2005). W analizach wykorzystano oficjalną klasyfikację sektorów przyjętą przez UE (M'Barek i in., 2018). Biogospodarka obejmuje: rolnictwo; leśnictwo; rybołówstwo i akwakulturę; żywność, napoje i tytoń; biotekstylia; bio: chemikalia, farmaceutyki, plastiki, gumy; papier; produkty drzewne i meble; biopaliwa płynne oraz bioenergię elektryczną. Na podstawie informacji dotyczących wartości dodanej, zatrudnienia oraz produktywności pracy w poszczególnych sektorach biogospodarki podjęto próbę wnioskowania na temat dynamiki zmian zaobserwowanych w latach 2008-2019 i możliwości rozwoju biogospodarki. Badane wskaźniki przedstawiono na tle całej UE-28.

Wyniki badań i dyskusja

Biogospodarka stanowi instrument wdrażania zrównoważonego rozwoju oraz istotną część gospodarki EU-28. W 2019 r. wygenerowała ponad 667 mld euro wartości dodanej. Analizując zmianę wartości dodanej w latach 2008-2019 zaobserwowano jej wzrost o 30,0%. Średnioroczny wzrost WD biogospodarki wynosił 15 mld euro (rys. 1). W analizowanym okresie wartość dodana w biogospodarce w Polsce wzrosła z 26,3 mld euro w 2008 r. do 36,9 mld euro w 2019 r., tj. 40,4%, a średnioroczny wzrost wyniósł 1,0 mld euro.



Rys. 1. Wartość dodana w biogospodarce w Polsce i UE-28 w latach 2008-2019

Fig. 1. Value added in the bioeconomy in Poland and EU-28 in 2008-2019

Źródło: opracowanie własne na podstawie Tamošiūnas i in. 2022.

Wartość dodana odzwierciedla zarówno możliwości produkcyjne, jak i ich rynkową realizację możliwą dzięki zapotrzebowaniu. Znajomość dynamiki zmian tworzenia wartości dodanej w poszczególnych sektorach oraz jej struktury sektorowej pozwala dokonać sektorowej dekompozycji źródeł wzrostu gospodarczego (Nowak i in., 2019).

W latach 2008-2019 zarówno w Polsce, jak i w EU-28 nastąpiły zmiany wartości dodanej w poszczególnych sektorach stanowiących komponent biogospodarki (tab. 1).

Tabela 1. Zmiana wartości dodanej i dynamika zmian w sektorach biogospodarki w Polsce i UE-28 w latach 2008-2019

Table 1. Change in value added and dynamics of changes in bioeconomy sectors in Poland and EU-28 in 2008-2019

Sektory biogospodarki	Polska			UE-28		
	2008	2019	Dynamika	2008	2019	Dynamika
	mld euro		%	mld euro		%
Rolnictwo	8,4	10,8	28,5	159,1	192,0	20,6
Leśnictwo	1,0	1,7	67,5	20,1	24,7	23,1
Rybołówstwo i akwakultura	0,0	0,1	74,6	5,4	5,8	7,1
Żywność, napoje, tytoń	10,1	14,0	38,7	175,1	237,5	35,6
Biotekstylia	0,9	0,9	-0,2	24,7	25,6	4,0
Produkty drzewne i meble	3,2	4,7	48,2	45,0	49,4	9,7
Papier	1,6	3,0	92,9	37,2	48,1	29,6
Bio: chemikalia, farmaceutyki, plastiki, gumy	1,0	1,3	38,5	43,0	74,2	72,6
Biopaliwa płynne	0,1	0,1	68,9	1,5	3,9	165,0
Bioenergia elektryczna	0,1	0,2	279,2	2,2	6,0	167,8

Źródło: jak rys. 1.

W analizowanym okresie w Polsce niewielki spadek dynamiki (-0,2%) odnotowano w sektorze biotekstyliów. W pozostałych sektorach – zarówno w Polsce, jak i w UE-28 – stwierdzono wzrost wartości dodanej. Najwyższą dynamiką wzrostu wartości dodanej w Polsce odznaczał się sektor bioenergii elektrycznej (279,2%) i była ona dużo większa niż w UE-28 (167,8%). Dużą dynamiką zmian w Polsce charakteryzowały się sektory: papierniczy, rybołówstwo i akwakultura, biopaliwa płynne oraz leśnictwo. Natomiast w UE-28 dużą dynamikę zmian odnotowano w sektorze biopaliw płynnych i bioproduktów (tab. 1).

Analiza struktury wartości dodanej poszczególnych sektorów w całej biogospodarce w Polsce wykazała, że największym udziałem charakteryzował się sektor żywności, napojów i tytoniu z wartościami 38,3% w 2008 r. i 37,8% w 2019 r. W UE-28 udział tego sektora wyniósł 34,1% i 35,6%, odpowiednio w 2008 i 2019 r. Należy przy tym zwrócić uwagę, że w UE-28 w analizowanym okresie odnotowano wzrost udziału tego sektora w całej biogospodarce, natomiast w Polsce niewielki spadek udziału (tab. 2). Sektor żywności, napojów i tytoniu generuje większą wartość dodaną niż rolnictwo. Świadczy to o tym, że w miarę rozwoju biogospodarki zmniejsza się rola rolnictwa w tworzeniu wartości dodanej brutto w stosunku do przemysłu żywności, napojów i tytoniu. Zarówno w Polsce, jak i UE-28 na drugiej pozycji pod względem udziału w całkowitej wartości dodanej biogospodarki uplasował się sektor rolnictwa. W 2008 r. rolnictwo wytworzyło 32,0% wartości dodanej całej biogospodarki, a 29,3% w 2019 r. Udział tego sektora w biogospodarce EU-28 wyniósł 31,0% i 28,8% odpowiednio w 2008 i 2019 r. Analiza wyników zaprezentowanych w tabeli 2 wskazuje, że sektory produkcji pierwotnej (poza leśnictwem w Polsce) powoli tracą na znaczeniu. W Polsce wzrosło znaczenie sektora produktów z drewna i mebli. W 2008 r. sektor ten wytworzył 12,0% udziału w wartości dodanej całej biogospodarki, a 12,7% w 2019 r. W analizowanym okresie wzrost udziału w WD biogospodarki odnotowano także w sektorze papierniczym i leśnictwie, a w UE-28 w sektorze bioproduktów. Niewielki wpływ na WD biogospodarki w Polsce i UE-28 miały sektory: rybołówstwa i akwakultury, biopaliw płynnych i bioenergii elektrycznej, z udziałem mniejszym lub równym 1%. W pozostałych sektorach stwierdzono spadek udziału wartości dodanej (tab. 2).

Tabela 2. Udziały procentowe sektorów w wartości dodanej całej biogospodarki w Polsce i UE-28 w latach 2008- 2019

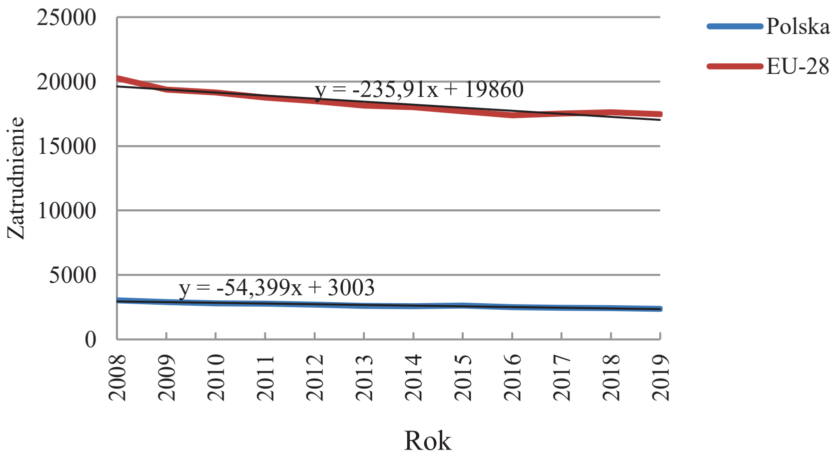
Table 2. Percentage shares of sectors in the value added of the entire bioeconomy in Poland and EU-28 in 2008-2019

Sektory biogospodarki	Polska		UE-28	
	2008	2019	2008	2019
	%		%	
Rolnictwo	32,0	29,3	31,0	28,8
Leśnictwo	3,9	4,6	3,9	3,7
Rybołówstwo i akwakultura	0,2	0,2	1,0	0,9
Żywność, napoje, tytoń	38,3	37,8	34,1	35,6
Biotekstylia	3,4	2,4	4,8	3,8
Produkty drzewne i meble	12,0	12,7	8,8	7,4
Papier	6,0	8,2	7,2	7,2
Bio: chemikalia, farmaceutyki, plastiki, gumy	3,7	3,7	8,4	11,1
Biopaliwa płynne	0,3	0,4	0,3	0,6
Bioenergia elektryczna	0,2	0,6	0,4	0,9

Źródło: jak rys. 1.

Transformacja w stronę zrównoważonego społeczeństwa i gospodarki stwarza szansę na wzrost zatrudnienia i zmianę aktualnych miejsc pracy we wszystkich sektorach, zarówno nowych, związanych z zaawansowanymi technologiami, jak również w tych tradycyjnych, np. rolnictwie, rybołówstwie.

Ważnym celem strategii biogospodarki jest tworzenie nowych miejsc pracy (EC, 2018). W 2019 r. biogospodarka UE-28 zatrudniała blisko 17,5 mln osób. Jednocześnie w latach 2008-2019 zaobserwowano spadek poziomu zatrudnienia (rys. 2). Analiza poziomu zatrudnienia w biogospodarce w Polsce również wskazuje na tendencję spadkową. Zatrudnienie w całym sektorze biogospodarki wynosiło w 2008 roku 3 034,8 tys. osób i zmalało w 2019 r. do 2 369,1 tys. osób, to jest o 22%. Średnioroczny spadek liczby osób zatrudnionych w biogospodarce Polski był w badanym okresie niższy niż przeciętnie w UE-28 i wynosił 54,4 tys. osób (rys. 2).



Rys. 2. Zatrudnienie w biogospodarce w Polsce i UE-28 w latach 2008-2019

Fig. 2. Employment in the bioeconomy in Poland and the EU-28 in 2008-2019

Źródło: jak rys. 1.

W analizowanym okresie odnotowano zmiany zatrudnienia w poszczególnych sektorach (tab. 3). Zarówno w Polsce, jak i UE-28 największy spadek zatrudnienia stwierdzono w sektorze biotekstyliów. Redukcję nadzatrudnienia odnotowano także w rolnictwie. W Polsce, w początkowym roku analizy, w sektorze tym zatrudnionych było 2 128,1 tys. osób i wartość ta spadła osiągając w 2019 roku 1 418,7 tys. osób (tab. 3).

Tabela 3. Zmiana zatrudnienia i dynamika zmian w sektorach biogospodarki w Polsce i UE-28 w latach 2008-2019

Table 3. Change in employment and dynamics of changes in bioeconomy sectors in Poland and EU-28 in 2008-2019

Sektory biogospodarki	Polska			UE-28		
	2008	2019	Dynamika	2008	2019	Dynamika
	tys. osób		%	tys. osób		%
Rolnictwo	2 128,1	1 418,7	-33,3	11 358,1	8 835,9	-22,2
Leśnictwo	62,0	63,0	1,6	513,0	516,4	0,7
Rybołówstwo i akwakultura	6,3	5,1	-19,0	190,2	160,3	-15,7
Żywność, napoje, tytoń	445,3	474,4	6,5	4 388,3	4 657,3	6,1
Biotekstylia	95,0	60,9	-35,9	1 124,7	789,8	-29,8
Produkty drzewne i meble	223,8	240,5	7,5	1 618,1	1 340,1	-17,2
Papier	48,7	70,1	43,8	650,0	631,7	-2,8
Bio: chemikalia, farmaceutyki, plastiki, gumy	22,3	32,6	46,0	398,5	466,5	17,1
Biopaliwa płynne	2,5	3,3	34,9	14,6	26,7	82,9
Bioenergia elektryczna	0,7	2,1	200,9	11,8	34,7	194,2

Źródło: jak rys. 1.

Redukcja zatrudnienia w rolnictwie wyniosła więc 33,3%, co wynikało z przekształceń strukturalnych (modernizacji procesów produkcji i konsolidacji własności oraz użytkowania ziemi rolniczej) w tym sektorze (Nowak i in., 2019). Nie jest to zjawisko niepokojące, a raczej nieunikniona korekta nadzatrudnienia, w wyniku której warunki bytowania pozostałych zatrudnionych mogą się nieco poprawić, choć nadal pozostaną niewystarczająco zadawalające. Zbyt duże zasoby pracy w rolnictwie zniechęcają do podejmowania działań w kierunku unowocześniania produkcji, ponieważ inwestowanie lub korzystanie z usług jest niekonkurencyjne ekonomicznie wobec pracy rolnika i członków rodziny (taniego zasobu pracy). Kołodziejczak (2018) zwrócił także uwagę na dofinansowanie ze środków WPR, jakie mogą pozyskać rolnicy. Z jednej strony widoczny jest korzystny wpływ WPR na zmiany strukturalne, z drugiej zaś dopłaty niezwiązane z wielkością produkcji rolniczej mogą zmniejszać motywację do poszukiwania pracy, a tym samym niekorzystnie oddziaływać na zmianę zatrudnienia w rolnictwie, zwłaszcza w gospodarstwach nieefektywnych ekonomicznie. Istotnym problemem jest także poziom kwalifikacji. Rozwój biogospodarki wymaga silnego wsparcia edukacyjnego, przekwalifikowania i ciągłego doskonalenia zawodowego. Pomimo szeregu barier, wobec wyczerpywania się możliwości wzrostu wartości dodanej (nadwyżki) generowanej przez rolnictwo, drogą do minimalizacji dysparytetu dochodowego rolników jest zmniejszenie zatrudnienia w sektorze rolnym. Cechą charakterystyczną i słabością polskiego rolnictwa pod względem ekonomicznym jest jego nadmierne rozdrobnienie agrarne. Konsekwencją rozdrobnienia agrarnego jest nie tylko niewielka skala produkcji większości gospodarstw, ale też duże zatrudnienie w rolnictwie, co powoduje niską dochodowość. Tak więc duży wpływ na redukcję dysparytetu dochodowego rolników ma przyspieszenie procesów koncentracji struktury agrarnej. Wzrost liczby gospodarstw dużych obszarowo wpłynął na wzrost skali produkcji. W literaturze podkreśla się także znaczenie środków budżetowych kierowanych do rolnictwa, czy to z budżetu krajowego, czy z budżetu środków europejskich. Fundusze kierowane do rolnictwa z jednej strony wprost zasilają dochody rolników (dopłaty bezpośrednie), z drugiej zaś wpływają na dochody poprzez wzrost nakładów inwestycyjnych w gospodarstwach rolnych (Kata, 2020).

W UE-28 spadek zatrudnienia w rolnictwie wyniósł 22,2%. Na podstawie danych Eurostat (2023) można zauważyć, że w krajach o wysokim poziomie rozwoju zatrudnienie w rolnictwie pozostaje na stabilnym, niskim poziomie.

W Polsce redukcję zatrudnienia odnotowano także w sektorze rybołówstwa i akwakultury. Natomiast w UE-28 spadek liczby osób pracujących stwierdzono w sektorze produktów drzewnych i mebli, rybołówstwa i akwakultury oraz w przemyśle papierniczym.

W pozostałych sektorach bigospodarki w Polsce i UE-28 odnotowano wzrost zatrudnienia.

Największą dynamiką zmian pod względem ilości osób pracujących odznaczał się sektor bioenergii elektrycznej. W Polsce w latach 2008-2019 odnotowano w tym sektorze wzrost zatrudnienia o 200,9%, a w UE-28 o 194,2%. Odchodzenie od gospodarki opartej na konwencjonalnych źródłach energii ma i będzie miało istotny wpływ na zatrudnianie pracowników w sektorach energetyki opartej na alternatywnych źródłach energii. Miejsca pracy związane z odnawialnymi źródłami energii wpisują się w zagadnienia ochrony środowiska oraz promocji zrównoważonego rozwoju (Kupczyk i in. 2017). Pozostałymi sektorami odznaczającymi się wzrostem zatrudnienia zarówno w Polsce, jak i na poziomie UE-28 są: leśnictwo; żywność, napoje i tytoń; bioprodukty oraz biopaliwa płynne (tab. 3). Można jednocześnie zauważyć, że wzrost ten był znacznie większy w Polsce niż w UE-28. W Polsce w sektorze bioproduktów zatrudnienie wzrosło o 46,0%, z 22,3 tys. do 32,6 tys. osób, a w UE-28 przyrost ten wynosił 17,1%. W sektorze tym skupiona jest głównie wysoka biotechnologia, więc wzrost ten jest bardzo pożądany dla rozwoju biogospodarki. Jedynie w przypadku biopaliw płynnych zmiana liczby osób pracujących w tym sektorze w UE-28 wynosiła 82,9% i była większa niż w Polsce (34,9%). Zatrudnienia te zapewne będą rosły w związku ze zwiększonymi naciskami na samowystarczalność energetyczną po agresji Rosji na Ukrainę.

Analizując strukturę zatrudnienia w biogospodarce można zauważyć, że różni się ona pomiędzy Polską i UE-28 (tab. 4).

Tabela 4. Udziały procentowe sektorów w zatrudnieniu całej biogospodarki w Polsce i UE-28 w latach 2008-2019

Table 4. Percentage shares of sectors in the employment of the entire bioeconomy in Poland and EU-28 in 2008-2019

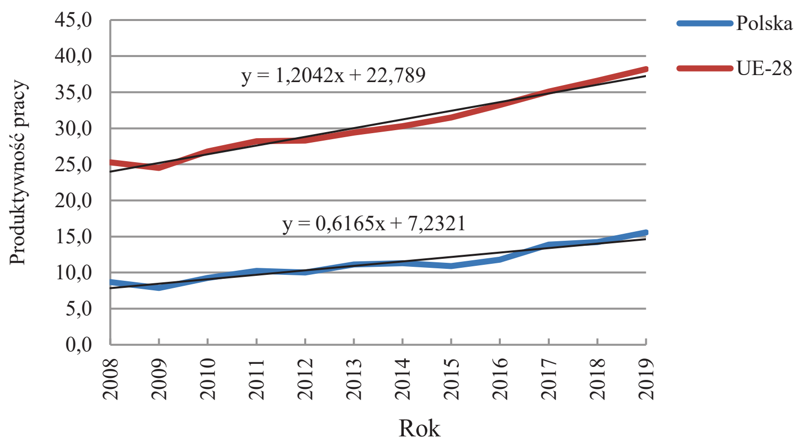
Sektory biogospodarki	Polska		UE-28	
	2008	2019	2008	2019
	%		%	
Rolnictwo	70,1	59,8	56,0	50,6
Leśnictwo	2,0	2,7	2,5	3,0
Rybołówstwo i akwakultura	0,2	0,2	0,9	0,9
Żywność, napoje, tytoń	14,7	20,0	21,7	26,7
Biotekstylia	3,1	2,6	5,5	4,5
Produkty drzewne i meble	7,4	10,1	8,0	7,7
Papier	1,6	3,0	3,2	3,6
Bio: chemikalia, farmaceutyki, plastiki, gumy	0,7	1,4	2,0	2,7
Biopaliwa płynne	0,1	0,1	0,1	0,2
Bioenergia elektryczna	0,0	0,1	0,1	0,2

Źródło: jak rys. 1.

Duża różnica występuje w odsetku pracujących w rolnictwie w porównaniu do innych sektorów. Zatrudnienie w tym sektorze w 2019 r. w polskiej biogospodarce wynosiło 59,8%, pomimo spadku w stosunku do roku 2008. W skali UE-28 odsetek ten był o 9 punktów procentowych niższy. Drugim sektorem pod względem udziału w całkowitym zatrudnieniu w biogospodarce jest produkcja żywności, napojów i tytoniu. W analizowanym okresie zarówno w Polsce, jak i UE-28 odnotowano wzrost tego sektora w zatrudnieniu całej biogospodarki. W 2019 r. sektor ten zatrudniał w UE-28 26,7% pracujących w biogospodarce. W Polsce udział ten był nieco niższy i wynosił 20%. Wzrost udziału liczby osób pracujących odnotowano w leśnictwie, przemyśle papierniczym i sektorze bioproduktów. W Polsce nastąpił też wzrost zatrudnienia w sektorze drzewnym i mebli, podczas gdy w skali EU-28 miał miejsce spadek. Redukcję liczby osób pracujących odnotowano w sektorze biotekstyliów. W pozostałych sektorach biogospodarki Polski i UE-28 stwierdzono niewielki wzrost zatrudnienia wynoszący mniej niż 1%.

Produktywność pracy odzwierciedla relację całkowitych efektów uzyskanych w przedsiębiorstwie do poniesionych nakładów pracy. Wzrost produktywności pracy postrzegany jest jako ważne źródło wzrostu ekonomicznego, postępu, a także poprawy poziomu życia społeczeństwa (Gołaś, 2011).

W latach 2008-2019 zarówno w biogospodarce w Polsce, jak i UE-28 odnotowano wzrost produktywności pracy (rys. 3). W 2008 r. w UE-28 produktywność pracy wynosiła 25,3 tys. euro na jednego pracownika^{-1} i do 2019 r. wzrosła do poziomu 38,2 tys. euro na zatrudnionego^{-1}, tj. o 51,0%. Średnioroczny wzrost wydajności pracy wyniósł 1,2 tys. euro na pracownika^{-1}. W biogospodarce Polski produktywność pracy w 2019 r. osiągnęła poziom 15,6 tys. euro na zatrudnionego-1. Pomimo wzrostu wydajności pracy o 79,6%, jest ona o połowę niższa niż w UE-28. Średnioroczny wzrost produktywności pracy w biogospodarce Polski wyniósł 0,6 tys. euro na jednego zatrudnionego^{-1}.



Rys. 3. Produktywność pracy w biogospodarce w Polsce i UE-28 w latach 2008-2019

Fig. 3. Labor productivity in the bioeconomy in Poland and the EU-28 in 2008-2019

Źródło: jak rys. 1.

Zmiany zachodzące w zakresie poziomu produktywności pracy w poszczególnych sektorach charakteryzowały się bardzo zróżnicowaną dynamiką. Analiza dynamiki zmian produktywności pracy w latach 2008-2019 w Polsce wykazała spadek produktywności pracy o 5,1% w sektorze bioproduktów. W UE-28 sektor ten charakteryzował się wysokim poziomem dynamiki zmian wynoszącym 47,5%. Natomiast największym wzrostem poziomu produktywności pracy w Polsce odznaczał się sektor rybołówstwa i akwakultury – o 115,7% w stosunku do roku 2008. Pomimo tak znaczącego wzrostu, produktywność pracy w tym sektorze w 2019 r. wynosiła tylko16,2 tys. euro na zatrudnionego-1. Wynikało to z bardzo niskiego poziomu produktywności pracy na początku badanego okresu. Podobną tendencję obserwujemy w sektorze rolnictwa. Zarówno w Polsce, jak i w UE-28 bardzo duża okazała się relacja dynamiki wzrostu wartości dodanej do dynamiki wzrostu liczby pracujących w sektorze rolnictwa. Wartość dodana w tym sektorze w analizowanym okresie wzrosła o 28,5% oraz 20,6% odpowiednio w Polsce i UE-28 (tab. 1), podczas gdy liczba osób zatrudnionych zmalała o 33,3% oraz 22,2% (tab. 3). Ostatecznie, w 2019 r. produktywność pracy w rolnictwie w Polsce wyniosła 7,6 tys. euro na pracownika^{-1}, a w UE-28 była prawie trzykrotnie większa i wyniosła 21,7 tys. euro na zatrudnionego^{-1}. Tak więc rolnictwo jako sektor nadal charakteryzuje się niską produktywnością pracy. Przy ograniczonej możliwości zwiększania produkcji rolnej to produktywność pracy decyduje o poziomie dochodów rolników, ponieważ określa liczbę osób, między które będzie dzielony uzyskany dochód. Przekłada się to na poziom i jakość życia mieszkańców wsi. Potwierdzają to badania przeprowadzone przez Gołębiewskiego (2020).

Ogromną różnicę w poziomie produktywności pracy można zaobserwować porównując sektor rolnictwa i bioenergii elektrycznej. W 2019 r. produktywność pracy w sektorze bioenergii elektrycznej była najwyższa. W Polsce osiągała ona wartość 112,2 tys. euro na zatrudnionego^{-1}, a w UE-28 wyniosła 171,6 tys. euro na zatrudnionego^{-1}. Zarówno w Polsce, jak i UE-28 sektor bioenergii elektrycznej był liderem w dynamice wzrostu wartości dodanej, która wynosiła odpowiednio 279,2% i 167,8% (tab. 1). Jednak sektor ten charakteryzował się również bardzo dużą dynamiką wzrostu liczby pracujących, wynoszącą odpowiednio 200,9% i 194,2% (tab. 3). Relacja ta znalazła odzwierciedlenie w niskim poziomie dynamiki zmian w produktywności pracy (tab. 5). W Polsce odnotowano wzrost produktywności pracy w tym sektorze o 26,0%, a w UE-28 spadek o 9,0%. Może to świadczyć o powolnym wyrównywaniu się poziomu produktywności pracy pomiędzy sektorami.

Dużą dynamikę zmian produktywności pracy w Polsce stwierdzono w leśnictwie i sektorze biotekstyliów, która wyniosła odpowiednio 64,9% i 55,6% (tab. 5). Jednak wzrost produktywności pracy w tych sektorach w 2019 r. wynosił tylko 27,2 tys. euro na zatrudnionego-1 oraz 14,6 tys. euro na zatrudnionego^{-1}. W UE-28 pomimo większej dynamiki zmian produktywności pracy (48,1%) w sektorze biotekstyliów osiągnęła ona poziom 32,5 tys. euro na zatrudnionego^{-1}, natomiast przy wzroście wynoszącym 22,3% w leśnictwie, produktywność pracy wyniosła 47,9 tys. euro na jedną osobę zatrudnioną$^{-1}$.

Tabela 5. Zmiana produktywności pracy i dynamika zmian w sektorach biogospodarki w Polsce i UE-28 w latach 2008-2019
Table 5. Change in labor productivity and dynamics of changes in bioeconomy sectors in Poland and EU-28 in 2008-2019

Sektory biogospodarki	Polska			UE-28		
	2008	2019	Dynamika	2008	2019	Dynamika
	tys. euro na zatrudnionego^{-1}		%	tys. euro na zatrudnionego^{-1}		%
Rolnictwo	4,0	7,6	92,8	14,0	21,7	55,1
Leśnictwo	16,5	27,2	64,9	39,1	47,9	22,3
Rybołówstwo i akwakultura	7,5	16,2	115,7	28,2	35,9	27,1
Żywność, napoje, tytoń	22,6	29,4	30,2	39,9	51,0	27,8
Biotekstylia	9,4	14,6	55,6	21,9	32,5	48,1
Produkty drzewne i meble	14,1	19,4	37,9	27,8	36,9	32,4
Papier	32,3	43,3	34,2	57,2	76,2	33,3
Bio: chemikalia, farmaceutyki, plastiki, gumy	43,6	41,3	-5,1	107,9	159,1	47,5
Biopaliwa płynne	34,3	42,9	25,2	100,2	145,2	44,9
Bioenergia elektryczna	89,0	112,2	26,0	188,4	171,6	-9,0

Źródło: jak rys. 1.

W 2019 r. w Polsce większą produktywnością pracy charakteryzował się przemysł papierniczy (43,3 tys. euro na zatrudnionego-1), jednak była ona o ponad 1,5 razy mniejsza niż w UE-28. Nieco mniejszą produktywność pracy odnotowano w Polsce w sektorze biopaliw płynnych i wynosiła ona 42,9 tys. euro na pracownika-1. W UE-28 produktywność pracy w tym sektorze była ponad trzykrotnie wyższa. Generalnie produktywność pracy we wszystkich sektorach w UE-28, zarówno na początku analizowanego okresu (2008 r.), jak i na końcu okresu (2019 r.) była wyższa niż w Polsce. Również badania Lakener i in. (2021) wskazują, że produktywność pracy w polskiej biogospodarce jest dwukrotnie niższa niż w pozostałych krajach Grupy Wyszehradzkiej. Wynika to z nadmiernego rozdrobnienia agrarnego polskiego rolnictwa.

Podsumowanie

Narastające wyzwania związane z zanieczyszczeniem środowiska przyrod¬niczego wywołują potrzebę poszukiwania nowych ścieżek rozwoju. Odpowiedzią na te wyzwania jest strategia biogospodarki. Działanie biogospodarki ukierunkowane na zmniejszenie zanieczyszczeń, ograniczanie degradacji środowiska, zapewnienie bezpieczeństwa żywnościowego, powstawanie nowych miejsc pracy, ułatwianie prowadzenia produkcji rolnej dzięki zaawansowanym technologiom przyczynia się do dobrobytu i wzrostu jakości życia ludzi.

Biogospodarka posiada duży potencjał oddziaływania na rozwój gospodarczy i społeczny. Rozwój biogospodarki realizowany w oparciu o innowacje przyczynia się do wzrostu wartości dodanej, zatrudnienia oraz poprawy produktywności pracy. Oczekuje się, że znaczenie biotechnologii i biogospodarki w różnych sektorach gospodarki wzrośnie, co przełoży się na wzrost wskaźników. Gołębiewski (2013) zauważył, że postęp w naukach przyrodniczych powoduje, że biogospodarka rozwija się bardzo dynamicznie, a tym samym staje się jednym z największych pracodawców. Również Pajewski (2014) przewiduje, że biogospodarka powinna prowadzić do uzyskania korzyści ekonomicznych i społecznych oraz mając duży potencjał, może doprowadzić do wzrostu gospodarczego.

Przeprowadzona analiza wykazała wzrost wartości dodanej w biogospodarce zarówno Polski, jak i w skali UE-28. W latach 2008-2019 wzrost wartości dodanej biogospodarki wyniósł odpowiednio 40,4% i 30,0%. Udział poszczególnych sektorów w WD biogospodarki był zróżnicowany. Wiodącą pozycję odgrywały pod tym względem żywność, napoje i tytoń oraz rolnictwo. Łączny ich udział w wartości dodanej biogospodarki w 2019 r. w Polsce wynosił 67,1%, a w UE-28 64,6%. W Polsce większe znaczenie niż w UE-28 miała też produkcja produktów z drewna i mebli, która w 2019 r. generowała 12,7% WD biogospodarki.

Ważnym elementem określającym potencjał biogospodarki jest liczba osób zatrudnionych, determinująca produktywność pracy. Wprawdzie w latach 2008-2019 zatrudnienie w biogospodarce w Polsce i UE-28 zmniejszyło się, jednak wciąż pracowało odpowiednio ponad 2,3 mln oraz 17,5 mln osób. Największą redukcję zatrudnienia odnotowano w sektorze biotekstyliów oraz w rolnictwie. W Polsce odpływ pracujących stwierdzono także w sektorze rybołówstwa i akwakultury. Natomiast w UE-28 spadek liczby osób pracujących stwierdzono w sektorze produktów drzewnych i mebli, rybołówstwa i akwakultury oraz w przemyśle papierniczym. W pozostałych sektorach biogospodarki wystąpiła tendencja rosnąca w zatrudnieniu, największa w sektorze bioenergii elektrycznej. Zaobserwowano także zmiany w strukturze pracujących w biogospodarce. Zarówno w Polsce, jak i UE-28 do sektorów o największym znaczeniu z punktu widzenia miejsc pracy należały rolnictwo, żywność, napoje i tytoń oraz produkty z drewna i meble. Rolnictwo zmniejszyło swój udział w strukturze zatrudnienia w stosunku do 2008 r., a w sektorze żywności, napojów i tytoniu zatrudnienie wzrosło. Podobną tendencję obserwujemy w UE-28.

Natomiast analizując produktywność pracy w poszczególnych sektorach polskiej biogospodarki w 2019 r., najwyższą jej wartość stwierdzono w przemyśle bioenergii elektrycznej (112,2 tys. euro na zatrudnionego-1), a najmniejszą w rolnictwie (7,6 tys. euro na zatrudnionego-1). W UE-28 we wszystkich sektorach biogospodarki produktywność pracy była wyższa niż w Polsce.

Główną ideą biogospodarki jest zastępowanie zasobów nieodnawialnych surowcami o charakterze odnawialnym. Istotną rolę odgrywa tu sektor rolnictwa, który wytwarza największą ilość biomasy. Uzyskana biomasa wykorzystywana jest jako surowiec w przemyśle spożywczym, paszowym, tekstylnym, drzewnym itp. i przekształcana w bioprodukty. Przekształcanie biomasy w produkty o wysokiej wartości dodanej wymaga nowych technologii, procesów i usług. W związku z tym, istotnym elementem rozwoju biogospodarki jest wsparcie dla badań i innowacji. Brak przemyślanych i konsekwentnie realizowanych polityk wspierających biogospodarkę oraz środków na jej rozwój będzie równoznaczny z zaprzepaszczeniem szans na lepsze życie ludzi zatrudnionych w całej biogospodarce i jej sektorach.

Literatura

Adamowicz, M. (2017). Biogospodarka – koncepcja, zastosowanie i perspektywy. *Zagadnienia Ekonomiki Rolnej*, 1(350), 29-49.

Brenne, R. (2022). European Bioeconomy Strategy: Stocktaking and future developments. Digitisation of biology for circular bioeconomy applications. 31 May 2022. Bioeconomy and Food System Unit, European Commission.

Bruckner, M., Häyhä, T., Giljum, S., Maus, V., Fischer, G., Tramberend, S., Börner, J. (2019). Quantifying the global cropland footprint of the European Union's non-food bioeconomy. *Environmental Research Letters*, 14 (4), 045011.

Czernyszewicz, E. (2016). Uwarunkowania i perspektywy rozwoju biogospodarki w Unii Europejskiej. *Problemy Rolnictwa Światowego*, 16(3), 49-56.

D'Adamo, I., Falcone, P. M., Martin, M., Rosa, P. (2020). A sustainable revolution: let's go sustainable to get our globe cleaner. *Sustainability*, 12(11), 4387.

Devaney, L., Henchion, M. (2018). Consensus, caveats and conditions: International learnings for bioeconomy development. *Journal of Cleaner Production*, 174, 1400-1411.

European Commission. (2012). Innovating for Sustainable Growth: A Bioeconomy for Europe. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Brussels, COM(2012) 60 final.

European Commission. (2017). Review of the 2012 European Bioeconomy Strategy. Luxembourg: Publications Office of the European Union.

European Commission. (2018). A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment. Publications Office of the European Union. Bruksela, COM(2018), 673 final.

EC JRC. (2018). Summary Report. Community of Practice Workshop. Setting the scene for monitoring the economic, environmental and social progress of the EU bioeconomy. Paper presented at, 2018, Brussels.

Eurostat. (2023). Baza danych. Pobrane 12 stycznia 2023 z:https://ec.europa.eu/eurostat/web/main/data/database.

Komisja Europejska. (2019). Komunikat Komisji do Parlamentu Europejskiego, Rady Europejskiej, Rady, Komitetu Ekonomiczno-Społecznego i Komitetu Regionów. Europejski Zielony Ład. COM(2019) 640 final.

Faber, A., Jarosz, Z. (2023). Charakterystyka zrównoważenia rozwoju biogospodarki w Polsce - wymiar ekologiczny. *Problemy Rolnictwa Światowego*, 23(1), 4-18.

FAO. (2018). Indicators to monitor and evaluate the sustainability of bioeconomy overview and a proposed way forward. Pobrane 12 stycznia 2023 z: http://www.fao.org/3/ca6048en/ca6048en.pdf.

Gołaś, Z. (2011). Czynniki kształtujące wydajność pracy w sektorze MSP Unii Europejskiej. *Journal of Agribusiness and Rural Development*, 4(22), 65-73.

Gołembiewski, B., Sick, N., Bröring, S. (2015). The emerging research landscape on bioeconomy: What has been done so far and what is essential from a technology and innovation management perspective? *Innovative Food Science and Emerging Technologies*, 29, 308-317.

Gołębiewski, J. (2013). Zrównoważona biogospodarka – potencjał i czynniki rozwoju. IX Kongres Ekonomistów Polskich, Warszawa.

Gołębiewski, J. (2020). Employment and added value in European Union bioeconomy – a sustainable development perspective. *Annals PAAAE*, 22(4), 74-83.

Gralak, A. (2021). Wdrażanie modelu gospodarczego opartego na obiegu zamkniętym w biogospodarce. *Problemy Rolnictwa Światowego*, 21(3), 24-40.

Holden, N.M. (2022). A readiness level framework for sustainable circular bioeconomy. *EFB Bioeconomy Journal*, 2, 100031.

Jander, W., Wydra, S., Wackerbauer, J., Grundmann, P., Piotrowski, S. (2020). Monitoring bioeconomy transitions with economic – environmental and innovation indicators: Addressing data gaps in the short term. *Sustainability*, 12 (11): 4683.

Kata, R. (2020). Wewnątrzsektorowe nierówności dochodów gospodarstw rolniczych w Polsce w latach 2004–2017. *Nierówności Społeczne a Wzrost Gospodarczy*, 61, 26-42.

Kołodziejczak, W. (2018). Zatrudnienie i wartość dodana brutto w sektorach państw Unii Europejskiej w latach 2002 i 2016. *Problemy Rolnictwa Światowego*, 18(40, 270-283.

Koukios, E., Monteleone, M., Carrondo, M.J.T., et al. (2018). Targeting sustainable bioeconomy: a new development strategy for Southern European countries. The Manifesto of the European Mezzogiorno. *Journal of Cleaner Production*, 172, 3931–3941.

Kuosmanen, T., Kuosmanen, N., El-Meligi, A., Ronzon, T., Gurria, P., Iost, S., M'Barek, R. (2020). How big is the bioeconomy? Reflections from an economic perspective. Publications Office of the European Union, Luxembourg.

Kupczyk, A., Mączyńska, J., Sikora, M., Tucki, K., Żelaziński, T. (2017). Stan i perspektywy oraz uwarunkowania prawne funkcjonowania sektorów biopaliw transportowych w Polsce. *Roczniki Naukowe Ekonomii Rolnictwa i Rozwoju Obszarów Wiejskich*, 104(1), 39–55.

Lakner, Z., Oláh, J., Popp, J., Balázs, E. (2021). The structural change of the economy in the context of the bioeconomy. *EFB Bioeconomy Journal*, 1, 100018.
Liobikiene, G., Balezenti, T., Streimikiene, D., Chen, X. (2019). Evaluation of bioeconomy in the context of strong sustainability. *Sustainable Development*, 27 (5), 955-964.
Lutzeyer, H. J. (2019). Introduction to the European Bioeconomy Strategy. SCAR-CASA Workshop, Carcavelos, Portugal, 20 May 2019.
Maciejczak, M., Hofreiter, K. (2013). How to define Bioeconomy. *Roczniki Naukowe SERIA*, 25(4), 244-246.
M'Barek, R., Parisi, C., Ronzon, T. (2018). Getting (some) numbers right – derived economic indicators for the bioeconomy, EUR 29353 EN, Publications Office of the European Union, Luxembourg.
Nowak, A., Kijek, T., Krukowski, A. (2019). Polskie rolnictwo wobec wyzwań współczesności, t. 1 – Wymiar ekonomiczno-strukturalny, Wydawnictwo Uniwersytetu Przyrodniczego w Lublinie.
Pajewski, T. (2014). Biogodpodarka jako strategiczny element zrównoważonego rolnictwa. *Roczniki Naukowe SERIA*, 16(5), 179-184.
Pellis, P., Cantone, S., Ebert, C., Gardossi, L. (2018). Evolving biocatalysis to meet bioeconomy challenges and opportunities. *New Biotechnology*, 40, 154-169.
Pink, M., Wojnarowska M. (red.). (2020). Biogospodarka. Wybrane aspekty. Difin, Warszawa.
Ronzon, T., M'Barek, R. (2018). Socioeconomic Indicators to monitor the EU's bioeconomy in transition. *Sustainability*, 10(6), 1745.
Scarlat, N., Dallemand, J.F., Monforti-Ferrario, F., Nita, V. (2015). The role of biomass and bioenergy in a future bioeconomy: Policies and facts. *Environmental Development*, 15, 3-34.
Scheiterle, L., Ulmer, A., Birner, R., Pyka, A. (2018). From commodity-based value chains to biomass-based value webs: The case of sugarcane in Brazil's bioeconomy. *Journal of Cleaner Production*, 172, 3851-3863.
Szewc-Rogalska, A. (2005). Produktywność czynnika ludzkiego w różnych formach własności przedsiębiorstw. *Nierówności Społeczne a Wzrost Gospodarczy*, 6, 127-133.
Tamošiūnas, S., Ronzon, T., Piotrowski, S., M'Barek, R., Carus, M., (2022). Jobs and wealth in the EU bioeconomy / JRC - Bioeconomics. European Commission, Joint Research Centre (JRC), [Dataset] PID: Pobrane 12 stycznia 2023 z: http://data.europa.eu/89h/7d7d5481-2d02-4b36-8e79-697b04fa4278.

Do cytowania / For citation:

Faber A., Jarosz Z. (2023). Zmiany i możliwości rozwoju biogospodarki w Polsce na tle Unii Europejskiej. *Problemy Rolnictwa Światowego*, 23(3), 4-19; DOI: 10.22630/PRS.2023.23.3.9

Faber A., Jarosz Z. (2023). Changes and Opportunities for the Development of Bioeconomy in Poland against the Background of the European Union (in Polish). *Problems of World Agriculture*, 23(3), 4-19; DOI: 10.22630/PRS.2023.23.3.9

Scientific Journal Warsaw University of Life Sciences – SGGW
Problems of World Agriculture volume 23(XXXVIII), number 3, 2023: 20-44
DOI: 10.22630/PRS.2023.23.3.10

Mohammed Sanusi Sadiq[1✉], Invinder Paul Singh[2], Muhammad Makarfi Ahmad[3], Mahmood Umar Bala[4]
[1,4] Federal University Dutse, Jigawa State, Nigeria
[2] Swami Keshwanand Rajasthan Agriculture University, Bikaner, India
[3] Bayero University, Kano, Nigeria

Food Insecurity Resilience Capacity of Rural Households in the Face of Induced-Weather Extremities in Bauchi State of Nigeria

Abstract. It is no longer a chasm that human existence is being threatened by induced-weather vagaries. Given the dynamic nature of the weather vagaries, if tacit actions are not taken on continuum basis, soonest, human race will go into extinction because of the steep devastating push effect of climate change. It is in lieu of the foregoing, that the researchers conceptualized a study that assessed rural households' food insecurity resilience capacity in Nigeria's Bauchi state using a resilience index measurement analysis (RIMA II), a novel methodological approach developed by FAO for studying such scenario, as literature review showed no evidence of its application in the study area. Adopting a multi-stage random sampling technique, a total of 322 households were randomly sampled from a sampling frame obtained by a reconnaissance survey. Using a well-structured questionnaire complemented with interview schedule, rural households' survey data were collected in the year 2022. Besides, the collected data were analyzed using both descriptive and inferential statistics. Empirically, it was established that the study area is challenged with food insecurity that owes majorly to poor food utilization and stability. Besides, poor food insecurity resilience capacity majorly due to vulnerable adaptive capacity was unmasked as the push effect behind food insecurity bane in the study area. However, evidence showed that food insecurity resilience capacity has a lasting effect on general well-being of rural households while households' hunger resilience capacity has a transitory effect as it can only contain food crises on the short-term basis. Nevertheless, income and consumption smoothening were the commonest short-term food coping strategies adopted in the study area. To achieve the sustainable development goals of zero hunger by 2030, it becomes imperative on policymakers to sensitize rural households on the need to adopt safe and eco-friendly improved indigenous food technologies so as to address the poor states of food utilization and stability affecting food security of the study area.

Keywords: food security, resilience, rural, sustainability, Nigeria

JEL Classification: I31, I32, Q12, Q18

Introduction

According to the Beyene et al. (2023), rural areas make up 59% of the population in developing nations and are crucial for the provision of food and other raw resources, the development of the national economy, the creation of jobs, and the preservation of natural

[1] Department of Agricultural Economics and Extension, FUD, P.M.B. 7156, Dutse, Nigeria,
e-mail: sadiqsanusi30@gmail.com; https://orcid.org/0000-0003-4336-5723; Corresponding author
[2] Department of Agricultural Economics, SKRAU, Bikaner, India; https://orcid.org/0000-0002-1886-5956
[3] Department of Agricultural Economics and Extension, BUK, Kano, Nigeria;
https://orcid.org/0000-0003-4565-0683
[4] Department of Agricultural Economics and Extension, FUD, Dutse, Nigeria;
https://orcid.org/0000-0004-5050-1599

areas (Mkupete et al., 2023). While rural areas are the backbone of the economy and make a sizable contribution to GDP (Sunday et al., 2023; Atara et al., 2020; Lascano Galarza, 2020), the sustainability of rural residents' livelihoods has been threatened by an increase in climatic stressors like droughts and anthropogenic forces, market volatility, and political unrest (Egamberdiev et al., 2023; Meyer, 2020). In many developing nations, this has resulted in unrelenting poverty and insufficient socioeconomic entitlements (d'Errico et al., 2023; Ado et al, 2022; Melketo et al., 2021; Dhraief et al., 2019).

Acute food insecurity has plagued millions of people in sub-Saharan Africa for the past 40 years due to harsh weather circumstances (Ouoba and Sawadogo, 2022; Sadiq et al., 2018a&b). The food system is currently subject to climate-related shocks every two years, which are nearly permanent in some regions (Bahta, 2022; Myeki and Bahta, 2021; Béné, 2020). These circumstances make it impossible for farmers in these nations or regions to recover from shocks (Merchant et al., 2022; Abebe, 2020; Ansah et al., 2019). This means that in order to more swiftly recover from food shocks, it's necessary to invest in the adaptability of communities and ecosystems. According to the UN, up to 65% of Africa's arable land has been degraded, and 45% of it has been damaged by desertification (Negesse et al., 2022). The World Food Programme (WFP), the United Nations Children's Fund (UNICEF), and the Food and Agriculture Organization of the United Nations (FAO), issued a joint statement at the Network for Food Crisis Prevention in West Africa (RPCA) annual meeting in Lomé in December 2022, sounding the alarm.

If urgent and long-term solutions are not discovered, these organizations warned that by the end of 2023, there will be more than 48 million hungry people in West and Central Africa, including 9 million children (Sadiq and Sani, 2022). African nations are also generally impacted by global economic fluctuations that threaten their food security, such as unstable commodity markets (Haile et al., 2022; Chamdimba et al., 2021), rising energy and fertilizer costs, snags in global trade (Ansah et al., 2023), as well as the ongoing situation in Ukraine. As a result of these shocks, food prices have sharply increased throughout the region, worsening food insecurity as persistent surge in the general price level (inflation) squeezes already-limited household finances and jeopardize social cohesion. All evidence points to the urgent need for sustainable solutions to be discovered in order to guarantee that future generations will have access to arable land that can support their demands.

The North-east of Nigeria consistently struggles with issues like poverty, resource depletion, climate change, and food and nutritional insecurity. Despite the mobilization and intervention of numerous actors to offer food help to the most vulnerable people, the region has experienced the biggest spike in starvation over the last ten years. The livelihoods of its inhabitants are under danger due to an increase in insecurity brought on by escalating conflict situations and millions of internally displaced persons (Agwu, 2023). Food security is a multifaceted notion that can be broadly classified into four basic categories: stability, availability, utilization, and access. Comprehending the application of these dimensions to Nigerian rural households offers a valuable understanding of the obstacles they have in guaranteeing a steady and dependable food supply.

The idea of resilience is increasingly being applied to development projects meant to increase rural households' and communities' ability to adapt, change, and cope with varieties of shocks and stressors (Calloway et al., 2022; Murendo et al., 2021; Nahid et al., 2021; Alhassan, 2020). However, there are still many obstacles to overcome before integrating the idea of resilience into food and nutrition security regulations and programming. This is mainly due to the fact that the concept can be best understood as being encased within constantly changing and highly specific processes that can be comprehended differently by different parties. Consequently, this has created a vacuum in research viz. knowledge, empirical, methodological and population gaps, thus the need for urgent information for policymakers and academic literature. It is in lieu of the foregoing that this research attempts to assess the food insecurity resilience capacity of rural households in the face of induced-weather extremities in Bauchi State of Nigeria. The specific objectives of the study were to determine the food insecurity status of the households; determine the food insecurity resilience capacity of the households; determine the effect of food insecurity resilience on food security and sustainable livelihood in the study area; and, to determine the food security coping strategies adopted by the households in the study area.

Research methodology

The state is situated between longitudes 8°45' and 11°0' East of the Greenwich meridian and latitudes 9°30' and 12°30' North of the equator. According to the 2006 census, Bauchi State had a population of 4,655,073 and was projected to have 7,685,312 inhabitants by 2021 (NPC, 2021). Due to its size and geographical changes, Bauchi State, which is located in northeastern Nigeria, has a wide range of agro-climatic conditions and has a landmass of 49,259km square. The state's location in the Sahel area, which has a semi-arid to sub-humid climate, has a significant impact on the state's climate. Typically, the rainy season starts in May and lasts through September or October. The majority of the state's yearly precipitation falls during this time. The dry season often begins in November and lasts through April. The Harmattan wind from the Sahara desert can blow during this time, bringing dry and dusty conditions along with the hot, dry weather. The climate in Bauchi State is often warm to hot all year round. During the dry season, temperatures are higher, frequently topping 30°C (86°F) during the day and occasionally going over 40°C (104°F) during the night. The state's vegetation ranges from guinea savannah in the south to savannah grasslands in the north. While Bauchi State's southern regions see comparatively higher rainfall and more intensive agricultural operations, the state's northern regions are more desert. In Bauchi State, agriculture has a vital economic role. The state frequently cultivates crops like millet, sorghum, maize, rice, and groundnuts. Additionally, raising cattle, sheep, and goats is quite important for the economy.

Using a multi-stage random sampling technique, a total of 322 respondents were chosen in households survey conducted in the year 2022. Firstly, all the stratified agricultural zones of Bauchi State Agricultural Development Project (BASADP) viz. Zone (A) Western, (B) Central and (C) Northern were selected as food insecurity is a general phenomenon. Subsequently, given the disproportionate distribution of the inherent LGAs across the strata, proportionate sampling technique was used to select the representative LGAs. Thereafter, from each of the selected LGAs, two villages were randomly selected. Based on the sample frame generated through reconnaissance survey (Table 1), Krejcie and Morgan (1970) formula (Equation 1) was used to determine the representative sample size. Thus, a total sample size of 322 households was randomly chosen for the study. A well-structured questionnaire coupled with interview schedule was used to collect the relevant information for the research. Hunger scale, dietary diversity score, food consumption score and food insecurity index were used to achieve objective I; resilience index measurement and analysis (RIMA II) and confirmatory factor were used to achieve objectives II and III; while IV was achieved using exploratory factor analysis. It is worth to mention that principal component analysis was used as a complimentary tool to generate food insecurity and RIMA II indexes.

$$n_p = \frac{N(X)}{X+(N-1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:

$X = \frac{Z^2 \; x \, P(1-P)}{e^2}$

n = Sample size;

N = Population size;

e = Acceptable sampling error;

X= Finite sample size;

P = Proportion of the population

Table 1. Sampling frame of rural households

Zones	LGAs	Villages	Sampling frame	Sample size
Western	Dass	Kagadama	3,230	9
		Wandi	9,210	26
	Kirfi	Badara	5,767	16
		Beni	5,322	15
	Tabawa-Baleawa	Burga	5,532	16
		Zango	4.127	12
	Toro	Polchi	4,241	12
		Zalau	5,300	15
Central	Ningi	Zidinga	3,403	10
		Tsangayan Dirya	5,350	15
	Darazo	Lanzai	9,120	26
		Yautare	8,423	24
Northern	Katagum	Chinede	5,437	15
		Ragwam	4,216	12
	Gamawa	Wabu	9,326	26
		Lariski	2,671	8
	Giade	Jugudu	3,310	9
		Hardori	3,221	9
	Misau	Akuyam	5,324	15
		Zindi	3,350	10
	Shira	Kilbore	2,320	7
		Yana	5,230	15
Total	**11**	**22**	**113,330**	**322**

Source: Reconnaissance survey, 2022.

Empirical models

1. ***Dietary diversity score:***

$DDS = \frac{\sum_{n=1} foods\ consumed}{Total\ household\ size}$ …………………..…….. (2)

2. ***Minimum normalization index***

$I = \frac{I_i - I_{min}}{I_{max} - I_{min}}$ ………………………………...……. (3)

Where: '*I*' is the indicator index, I_i is the value of the i^{th} indicator; I_{min} is the minimum value of the i^{th} indicator; and, I_{max} is the maximum value of the i^{th} indicator.

3. ***Dimension index***

$D_i = \sum_{i=1}^{n=0} \left(\frac{w_i * I_i + \ldots\ldots w_n * I_n}{w_i + \ldots. w_n} \right)$ ………………………… (4)

Where: D_i is the dimension index of i^{th} households and w is the weight of i^{th} Indicator index.

4. ***Food insecurity index***

$FISI = \frac{(AV^3 + AC^3 + U^3 + S^3)^{1/3}}{4}$ ………………………. (5) (Anand and Sen, 1997)

Where: AV= Availability; AC= Access; U= Utilization; and, S= Stability (Table 2).

5. ***RIMA-II***

Resilience is complex and difficult to measure because it cannot be immediately witnessed or measured. The FAO RIMA-I and RIMA-II approaches use a set of pillars to measure resilience, which are then combined using latent variable models. After RIMA-I was initially implemented in more than ten countries; FAO refined the process and created a second version in 2015 (FAO, 2015). Both direct and indirect indicators of resilience are included in the updated RIMA-II, which eventually leads to a more thorough evaluation of resilience and more reliable policy recommendations. Within a dynamic framework, RIMA-II shows statistically sound causal links between food security drivers and outcomes, as well as predicts the factors that influence changes in the capacity for resilience and food security. The direct measure in RIMA-II now consists of four pillars instead of the previous six pillars. Rather than being part of the estimate model, shocks and food security indicators are used as predictors (shocks) & resilience outcomes (food security) (FAO, 2016). The Resilience Capacity Index (RCI) and the Resilience Structure Matrix (RSM) are two tools used by RIMA-II to measure resilience directly (FAO, 2015). The former assesses a household's ability to withstand shocks and stressors and prevent long-term harm, while the latter indicates the relative importance of each pillar in determining resilience.

$RIMA - II = \frac{ABS + AST + SSN + AC}{W_{ABS} + W_{AST} + W_{SSN} + W_{AC}}$ … (6) (FAO, 2015 & 2016; Alinovi et al., 2008)

ABS=Access to basic services; AST=Assets; SSN=Social safety net; and, AC=Adaptive capacity (Table 3).

6. ***Confirmatory factor analysis (CFA)*:** The multiple indicator multiple cause (MIMC) belongs to structural equation model (SEM) family, and it combines two models of SEM viz. formative and reflective models. The distinction between these two models lies on causal structure. A formative model sees the observed variables as the cause of the latent variable while the reverse is the case for reflective model. Given below is the MIMC model:

$$\begin{bmatrix} LI \\ FS \\ Linc \end{bmatrix} = [\beta_{1-4}] * [\eta] + [\varepsilon_2, \varepsilon_6] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(7)}$$

$$[\eta] = [\delta_{1-5}] * \begin{bmatrix} ABS \\ AC \\ SSN \\ AS \\ Shock \end{bmatrix} + [\varepsilon_1] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8)}$$

$$\begin{bmatrix} LI \\ FS \\ INC \end{bmatrix} = [\alpha_{1-4}] * [\omega] + [\varepsilon_{14}, \varepsilon_{18}] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(9)}$$

$$[\omega] = [\gamma_{1-3}] * \begin{bmatrix} MS \\ IM \\ CC \end{bmatrix} + [\varepsilon_{1-13}] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(10)}$$

Where, MIMC for food insecurity resilience and hunger resilience are (Equations 7-8) and (Equations 9-10) respectively. η is food insecurity resilience capacity (FIRC), β_{1-4} is parameter estimates of FIRC, δ_{1-5} is parameter estimates of food security indicators (ABS, AC, SSN, AS) and shocks; ω is hunger resilience capacity (HRC), α_{1-4} is parameter estimates of FIRC, γ_{1-3} is parameter estimates of hunger coping strategies (MS= meal skipping, IM= inferior meal, and CC= consumption credit); LI is livelihood index, FS is food security index (short- DDS, medium- FSC and long- FS terms), IN is income, Linc is log income; and, ε_{1-n} is error term.

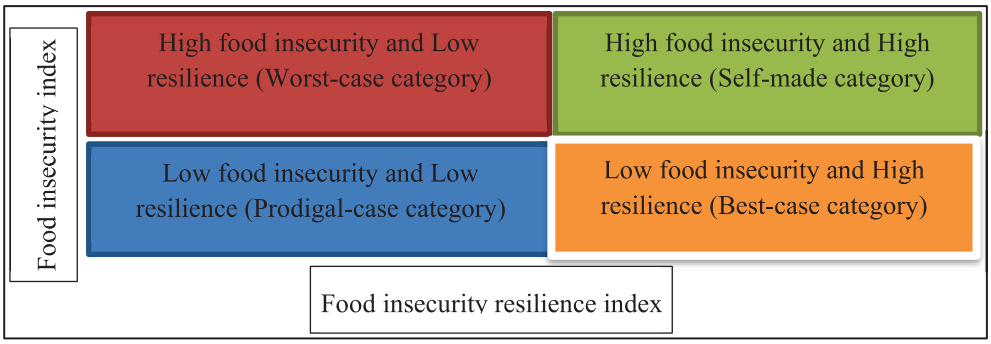


Fig. 1. Nexus between food insecurity and resilience index

Source: Ha-Mim *et al*. (2020).

Table 2. Dimensions and indicators of food insecurity

Dimensions	Indicators	Units
AV	Food expenditure per household	Naira per head
	Farm size	Hectare
	Number of farms	Number
	Land tenure ship	Type (rent, inheritance, etc)
	Food purchased capacity	Naira
	Food stock for over 2-6 months	Naira
	Quantity of food assistance	Naira
	Income from sales of crop	Naira
	Income from sales of Livestock	Naira
	Quantity of purchased food product from the market	Naira
	Quantity obtained from fishing/wild gathering	Naira
	Income diversification	Number
	Availability of wild food	Yes/No
	Monthly purchasing power/ monthly income	Naira
AC	Transport Cost for farm produce & livestock	Naira
	Availability of road market infrastructure	Yes/No
	Distance to market's road	Cost
	Availability of market	Yes/No
	Distance to market	Cost
	Labor exchange for Food	Naira
	Availability of storage facilities	Yes/No
	Capacity of storage facilities	Bag(s)
	Income from women and children	Naira
	Membership of trade association	Number
	Income from off-farm activities	Naira
	Income from farm activities	Naira
	Engagement in Non-Farm Employment	Number
	Engagement in dry season farming	Yes/No
ST	Household's production (output)	Naira
	Number of months of rainfall	Number
	Drought, Erosion, flood	Yes/No
	Political crises/ social unrest	Yes/No
	Price of a major commodity	Naira per month
UT	Disease affliction (diarrhoea, fever, cholera, etc)	Number
	Water supply source(s)	Number
	Number of meals per day	Number
	Number of meal variety per day	Number
	Number of food items consumed	Number
	Food habits	3-likert scale (H to P)
	Number of food preparation practices	Number
	Number of acceptable food preferences & substitutes	Number
	Availability of and access to milling facilities	Yes/No
	Adequate sanitation	4-Likert scale (H to VP)
	Access to health services	4-Likert scale (H to VP)

Note: H= High; P= Poor; and, VP= Very poor.

Source: Adopted and modified from Sadiq and Sani (2022).

Table 3. Dimensions and indicators of resilience

Dimension	Indicator	Unit
ABS	Access to telecommunication services	Yes/No
	Cost of transportation to health centre	Naira
	Cost of transportation to pharmacy	Naira
	Cost of transportation to market centre	Naira
	Cost of transportation to agro-service centre	Naira
	Cost of transportation to agro-processing centre	Naira
	Cost of transportation to primary school	Naira
	Cost of transportation to veterinary centre	Naira
AC	Access to credit service	Yes/No
	Income sources possessed	Number
	Numbers of crops cultivated in the last season	Number
	Perception on food security adaptive capacity level	4-likerst scale (VH to L)
	Number of food coping strategies adopted	Number
	Household's consumed balance diet in the last three days	3-likert scale (Yes to No)
	Extension services	Yes/No
	Membership of co-operative association	Yes/No
	Dependency ratio	%
	Education level	Years
	Number of household's members that have attended school	Number
SSN	Received food assistance from friends	Yes/No
	Perception on the importance food aid received	5-Likert scale (VI to NI)
	Remittance from family member	Yes/No
	Assistance from government	Yes/No
	Access to children scholarship	Yes/No
AST	Land ownership	Yes/No
	Livestock ownership	TLU
	Wealth	Index
	Agricultural Asset	Index

Note: VH= Very high; L= Low; TLU= Tropical livestock units; Naira = Nigerian currency.

Source: FAO (2015 & 2016).

Table 4. Weather-induced shocks' indicators

Indicators
Number of parasites attack on crop in the last 10 years
Number of parasites attack on livestock in the last 10 years
Number of livestock lost to pest and diseases in the last 10 years
Number of household's member(s) sick in the last 1 year
Number of flood/drought in the last 10 years
Number of fire outbreak either in the house or farm in the last 10 years

Source: FAO (2015 & 2016).

Results and discussion

A cursory review of hunger status, short-term food insecurity, revealed that majority (57.1%) of the rural households is at risk of hunger (Figure 2). Besides, slightly less than half (42.3%) of the sampled households were hungry while insignificant proportion (0.6%) of the rural populace escaped the voracious web of hunger in the study area. Therefore, it can be inferred that the rural populace are challenged with hunger, a short-term food insecurity challenge.

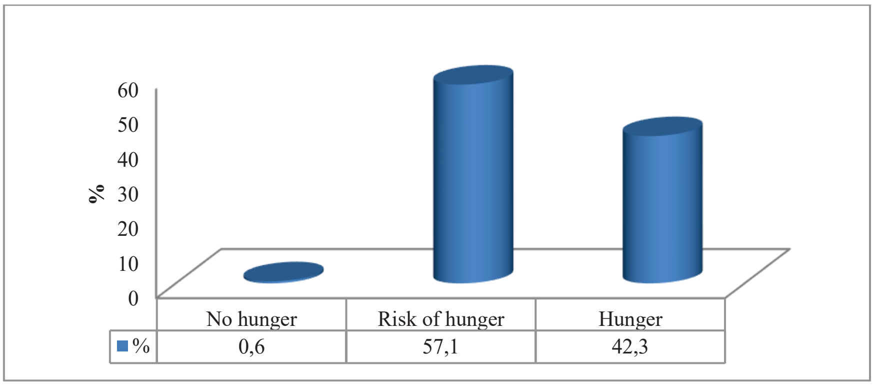


Fig. 2. Hunger scale of rural households

Source: Field survey, 2022.

As a rider, the average dietary diversity of households in the study area being 1.4 per head justified the height of hunger in the study area. Nevertheless, at a threshold of 4 meals per head as used by Mathye and Gericke (2019), almost all the rural households have poor dietary diversity vis-à-vis 84.3 and 11.9% respectively are faced with very poor and poor dietary diversities (Figure 3). Fortunately, 1.9% is at the threshold of vulnerability while a similar percent replica had a good dietary diversity per head in the study area. This state of heightened short-term food insecurity is a potential threat to the growth and development of the rural economy as it will not only heighten rural-urban migration that creates state of human nuisance in the state in particular and the country in general but will worsen the state of food security in general as rural economy still remains the pivot of food supply in a country whose economy is subsistence characterized.

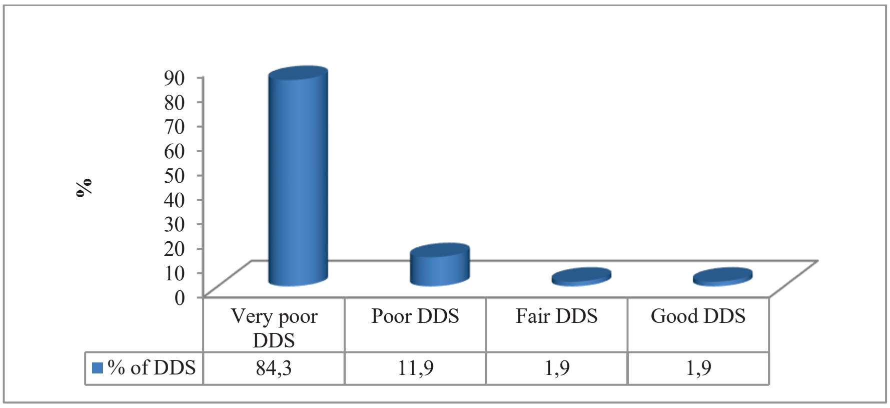


Fig. 3. Distribution of households' dietary diversity status

Source: Field survey, 2022.

Contrarily, in the med-term food security, majority of the rural households (55.2%) were off the threshold of food insecurity, i.e. were in acceptable fold of food consumption score (FCS), meaning they had good food consumption score status (Figure 4). However, slightly less than half (32.6%) of the rural households were vulnerable to food insecurity, i.e., were in the borderline fold of FCS classification while a handful of 12% were classified to have poor food consumption score status. Therefore, it can be inferred that in the mid-term, the rural economy is in the comfort zone of food security.

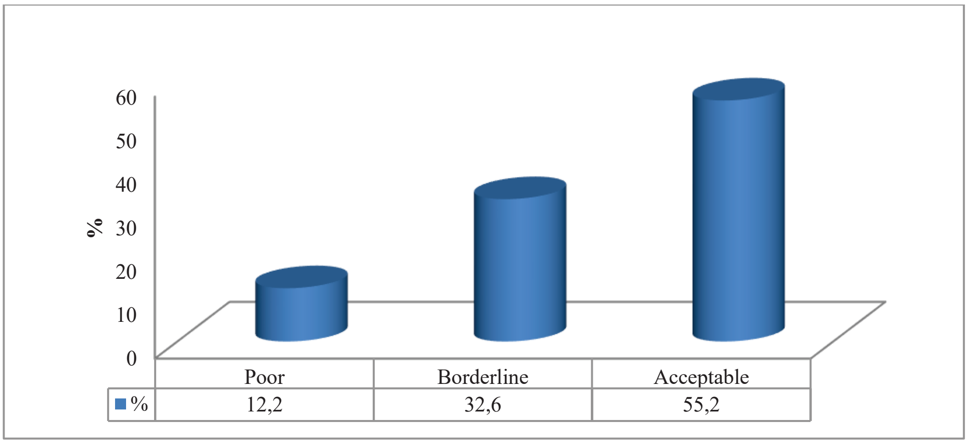


Fig. 4. Distribution of households' Food consumption score status

Source: Field survey, 2022.

Furthermore, on the average, the frame work of food insecurity in the long-term showed that food stability (60.54%) contributed most to food insecurity, followed by food utilization (50.88%), then food access (10.77%) and food availability (9.43%)(Figure 5). By implication, there is poor stability and utilization of food in the study area, thus the bane of food security. However, access and availability of food in the study area can be inferred to be fair but food being a precursor of life, more need to be done to make their status to be good. It is worth to mention, that the households should be enlightened on the need to explore the use of good indigenous technology of extend the shelf of food commodities especially the non-perishable ones, thereby ensuring stable and appropriate utilization of food. The poor stability and utilization of food owes to ineffective facilities- conventional and non-conventional value addition and storage technologies which makes rural households to treat most of the available and accessible food commodities as a flow resource rather than as a stock resource. Therefore, onus lies on households and policymakers to devise appropriate measures that will enhance households' food security in the rural economy before it cascade into a state of disaster in the state in particular and the country in general.

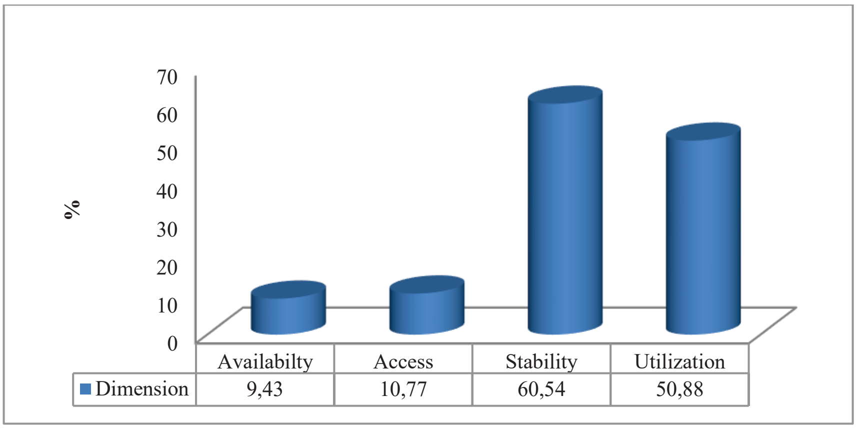
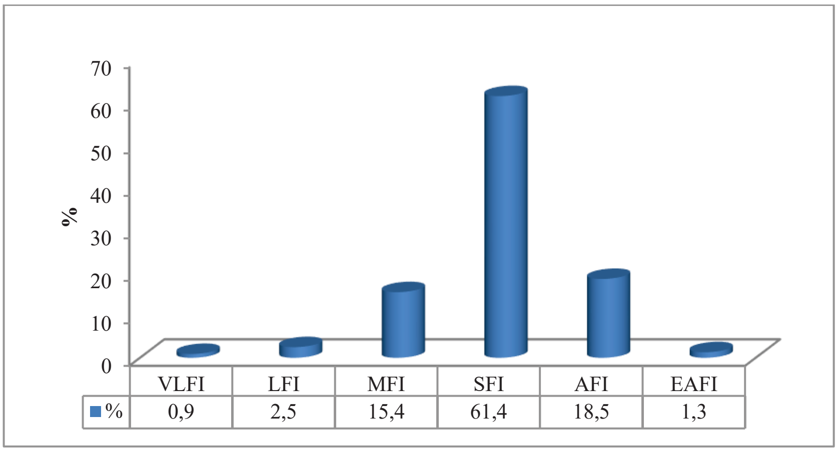


Fig. 5. Distribution of households' food security dimensions

Source: Field survey, 2022.

Moreover, it was established that majority (61.4%) of the households are in the state of serious food insecurity; 18.5% are in state of alarming food insecurity while 1.3% are challenged with extreme alarming food insecurity (Figure 6). Nevertheless, 15.4% are in the threshold of vulnerable-voracious state of food insecurity, i.e., moderate food insecurity while 2.5 and 0.9% households respectively are in the states of low and very low food insecurity. Generally, it can be inferred that the study area is in a peril condition owing to poor food stability and utilization, thus jeopardize what keeps the body and the soul together. Though the rural economy is not in a marathon race between life and death owing to its fair status in food availability and accessibility but it is obviously in a battle to keep the body and the soul together.



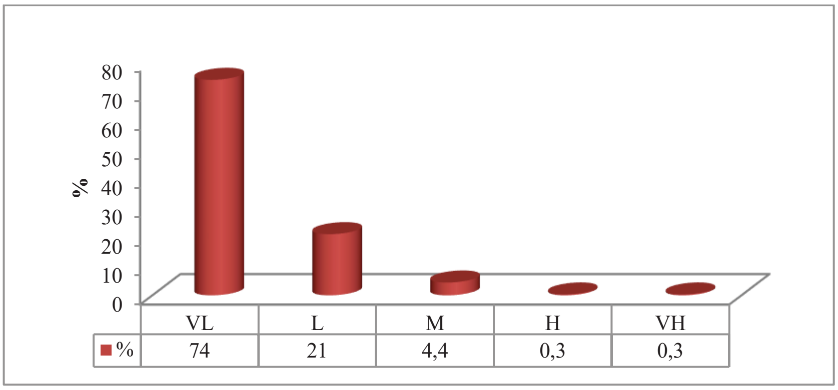
Note: VL=Very low; L=Low; M=Moderate; S=Severely; A=Alarming; EA=Extremely alarming; FI=Food insecurity.

Fig. 6. Distribution of households' food insecurity status

Source: Field survey, 2022.

Food Insecurity Resilience Capacity of Rural Households

A perusal of weather-induced shocks showed that majority (95%) of the households' had their food security to be affected by low weather-induced shocks vis-à-vis very low (74%) and low (21%)(Figure 7). However, it was observed that a handful of 4.4% had their food security to be affected by moderate weather-induced shocks while 0.6% encountered high weather-induced shocks that affected their food security.



Note: VL= Very low; L=Low; M=Moderate; H=High; and, VH=Very high

Fig. 7. Distributions of households' response to weather-induced shocks

Source: Field survey, 2022.

Empirically, using a direct approach, a cursory review of food insecurity resilience capacity index (RCI) showed that majority of the households had low food insecurity resilience capacity vis-à-vis 40.1% and 50.8% respectively with very low and low resilience capacity. However, 8.5% of the households had moderate food insecurity resilience capacity while the food insecurity resilience capacity of 0.6% was high (Figure 8). Nevertheless, a detailed view of the resilience structure matrix (RSM) showed adaptive capacity (AC) to be the pillar that contributed most to households' food insecurity resilience capacity in the study area, closely followed by social safety nets (SSN) and assets (AST) and then at distance, access to basic services (ABS) with least contribution (Figure 9a). In other words, on the average, the index contributions' status of all the food insecurity resilience indicators was poor and that of access to basic services being the worst as evident by their respective average index that was less than 13%. Besides, sub-pillar-wise, agricultural asset (AST4) contributed most to food insecurity resilience capacity, then followed by rural advisory services (extension services) (AC7) while the frequency of coping strategy (AC5) contributed least to food insecurity resilience capacity of the rural households in the study area (Figure 9b). Thus, the heightened poor food insecurity resilience capacity among majority of the households in the study area can be attributed to the worsen status of the pillars that determine resilience capacity against long lasting consequence of stresses and shocks on food security in the rural economy of the study area. Generally, it can be inferred that the households' resilience capacity to avoid shocks and stresses that have long lasting effects in the study area is poor, thus the need for a swift intervention before it cascade into a calamitous situation that will be pervaded with hunger, starvation and endangered health epidemics.

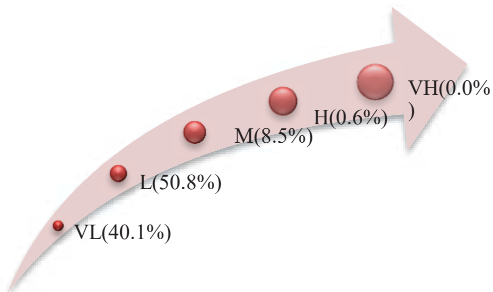


Fig. 8. Food insecurity distributions of households

Source: Field survey, 2022.

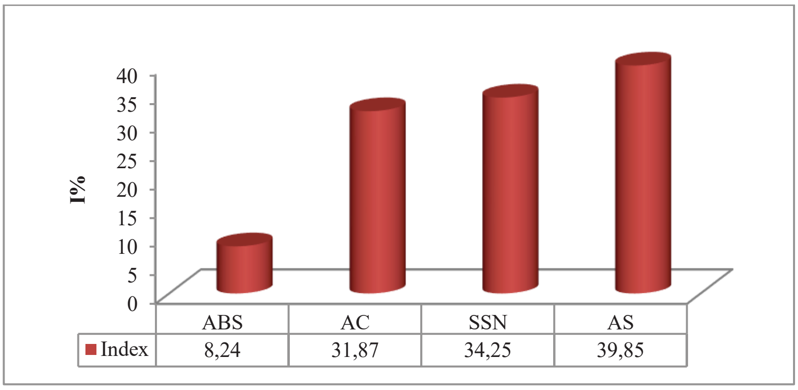


Fig. 9a Average index contribution of RC indicators

Source: Field survey, 2022.

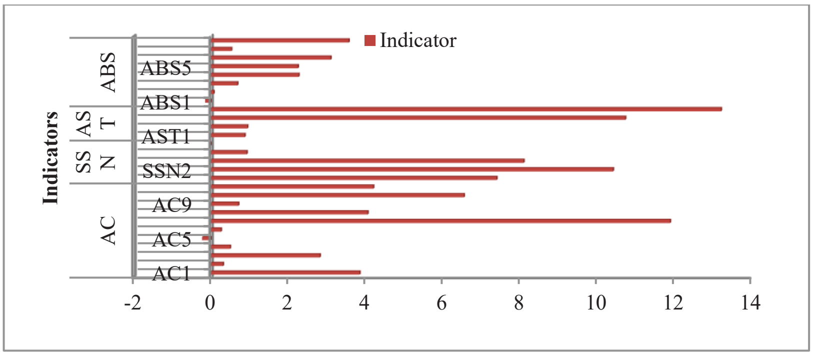


Fig. 9b. RSM contributions of sub-indicators (%)

Source: Field survey, 2022.

Using the indirect approach, structurally, except asset (AST), all the remain resilience pillars had significant influence on households' food insecurity resilience capacity (FIRC) as evident by their respective estimated coefficients that were different from zero at 10% probability level (Table 5a and Figure 10). Besides, except access to basic services (ABS), the duo of adaptive capacity (AC) and social safety nets (SSN) positively increased the households' resilience capacity towards food insecurity and this may be attributed to adoption of good contingency plan by the rural households with respect to the former and the support of effective implementation of national social intervention programme in the study area with respect to the latter. Nevertheless, the declining effect of ABS on households' resilience capacity may not be far from weak and ineffective infrastructural facilities in the study area. However, the insignificant influence of AST on households' resilience capacity may be attributed to the resource poor status of rural households given that in agrarian characterized rural settings of Nigeria, unlike social capital, the rural economy is challenged with serious limitation of economic capital. Empirically, any household stands the chance of having its food insecurity resilience capacity to increase by 2.04 and 0.34% respectively if it's AC and SSN increased by 1%. However, their resilience capacity stands to plummet by 1.47% if the state of infrastructural decay increased by 1%. In addition, the influence of weather-induced shocks was insignificant and the possible reasons are because weather vagaries exert mild effect on their food security as evidently established in the previous report on the influence of weather-induced shocks on food security; and, the buffer effects of AC and SSN that absolve the consequence of weather-induced shocks. Noteworthy, contrary to the a prior expectation, the positive sign associated with weather-induced shocks exhibit the active readiness of the rural households against any anticipated stress that will have a long term effect on their households' food security in the study area.

Furthermore, it was established that FIRC as a mediation factor significantly influenced short-term, mid-term, long-term food securities and sustainable livelihood (general wellbeing) of the rural households in the study area as evident by their respective estimated coefficients that were different from zero at 10% degree of freedom. Empirically, any given households have the chance of its short, mid, long-term food securities and sustainable livelihood to increase by 0.49, 3.70, 0.06 and 0.15% respectively for any given increase in its FIRC by 1%.

Table 5a: Effects of food insecurity resilience capacity on food security and sustainable livelihood

Variable (→)		Estimate (US)	Estimate (S)	SE	CR	P-value	R^2
ABS	FIRC	-1.472	-0.373	0.292	-5.044	***	
AC	FIRC	2.043	0.664	0.281	7.268	***	
SSN	FIRC	0.339	0.198	0.115	2.949	0.003**	0.626
AS	FIRC	0.343	0.065	0.342	1.002	0.316^{NS}	
SHOCK	FIRC	0.194	0.047	0.268	0.722	0.470^{NS}	
FIRC	LI	0.153	0.500	0.026	5.980	***	0.250
FIRC	FS	0.057	0.478	0.010	5.816	***	0.228
FIRC	FSC	3.700	0.223	1.151	3.214	0.001**	0.050
FIRC	DDS	0.494	0.192	0.176	2.807	0.005**	0.037
FIRC	Linc	1.000	0.501	-	-	-	0.251
Variance							
ABS	-	0.018	-	0.001	12.610	***	-
AC	-	0.030	-	0.002	12.610	***	-
SSN	-	0.098	-	0.008	12.610	***	-
AS	-	0.010	-	0.001	12.610	***	-
SHOCK	-	0.017	-	0.001	12.610	***	-
e1	-	0.107	-	0.039	2.730	0.006	-
e2	-	0.020	-	0.002	10.784	***	-
e3	-	0.003	-	0.000	11.021	***	-
e4	-	74.639	-	6.038	12.361	***	-
e5		1.821	-	0.147	12.429	***	-
e6		0.855	-	0.079	10.780	***	-

Note: ***, **, * & NS mean significant at 1, 5, 10% and non-significant respectively; US=Unstandardized; S=Standardized; SE=Standard error: CR=Critical ratio; P=Probability; R^2=Squared multiple correlation; →=relationship; e=error term; Linc=Logarithm of income.

Source: Field survey, 2022.

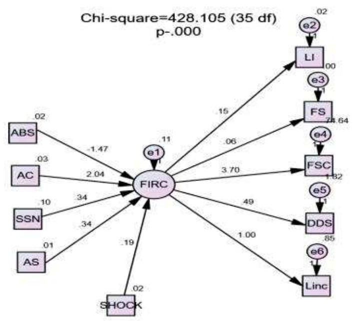


Fig. 10. Structural modeling of food insecurity resilience capacity

Source: Computer print-out, 2022.

Noteworthy, the respective total effects of AC, SSN, AST and ABS, the de facto pillars of resilience capacity, on short-term, mid-term, long-term food securities and sustainable livelihood are 1.010, 7.559, 0.116 and 0.313%; 0.168, 1.255, 0.019 and 0.052%; 0.170, 1.270, 0.020 and 0.030%; and, -0.728, -5.447, -0.084 and -0.225% respectively (Table 5b). Besides, weather-induced shocks' total effects on short-term mid-term, long-term securities and sustainable livelihood are 0.096, 0.717, 0.011 and 0.030% respectively. Nevertheless, the model fit results showed that the structural equation model best fit the specified equation as evident by its respective diagnostic statistics that are within the recommended thresholds (Table 5c).

Table 5b: Direct, indirect and total effects of latent and mediating variables on food security and sustainable livelihood

Variable	SHOCK	AS	SSN	AC	ABS	FIRC	SHOCK	AS	SSN	AC	ABS	FIRC
	Unstandardized						Standardized					
						Direct effect						
FIRC	0.194	0.343	0.339	2.043	-1.472	0.000	0.047	0.065	0.198	0.664	-0.373	0.000
Linc	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.501
DDS	0.000	0.000	0.000	0.000	0.000	0.494	0.000	0.000	0.000	0.000	0.000	0.192
FSC	0.000	0.000	0.000	0.000	0.000	3.700	0.000	0.000	0.000	0.000	0.000	0.223
FS	0.000	0.000	0.000	0.000	0.000	0.057	0.000	0.000	0.000	0.000	0.000	0.478
LI	0.000	0.000	0.000	0.000	0.000	0.153	0.000	0.000	0.000	0.000	0.000	0.500
						Indirect effect						
FIRC	0.000	0.000	0.000	0.000	.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Linc	0.194	0.343	0.339	2.043	-1.472	0.000	0.023	0.033	0.099	0.332	-0.187	0.000
DDS	0.096	0.170	0.168	1.010	-0.728	0.000	0.009	0.012	0.038	0.128	-0.072	0.000
FSC	0.717	1.270	1.255	7.559	-5.447	0.000	0.010	0.014	0.044	0.148	-0.083	0.000
FS	0.011	0.020	0.019	0.116	-0.084	0.000	0.022	0.031	0.095	0.317	-0.179	0.000
LI	0.030	0.053	0.052	0.313	-0.225	0.000	0.023	0.032	0.099	.332	-0.187	0.000
						Total effect						
FIRC	0.194	0.343	0.339	2.043	-1.472	0.000	0.047	0.065	0.198	0.664	-0.373	0.000
Linc	0.194	0.343	0.339	2.043	-1.472	1.000	0.023	0.033	0.099	0.332	-0.187	0.501
DDS	0.096	0.170	0.168	1.010	-0.728	0.494	0.009	0.012	0.038	0.128	-0.072	0.192
FSC	0.717	1.270	1.255	7.559	-5.447	3.700	0.010	0.014	0.044	0.148	-0.083	0.223
FS	0.011	0.020	0.019	0.116	-0.084	0.057	0.022	0.031	0.095	0.317	-0.179	0.478
LI	0.030	0.053	0.052	0.313	-0.225	0.153	0.023	0.032	0.099	0.332	-0.187	0.500

Source: Field survey, 2022.

Table 5c. Model fit summary

Category name	Index name	Obtained	Recommended
Absolute fit	CMIN	428.105	-
	DF	35	-
	P	0	p<=0.05
	RMSEA	0.078	< 0.08
	RMR	0.012	<0.02
	GFI	0.905	> 0.90
Incremental fit	AGFI	0.994	> 0.90
	NFI	0.96	> 0.90
	RFI	0.977	> 0.90
	TLI	0.99	> 0.90
	CFI	0.97	> 0.90
	IFI	0.98	> 0.90
	PGFI	0.913	> 0.90
	FMIN	0.9346	> 0.90
Parsimonious fit	CMIN/DF	2.232	< 5.0
Others	NPAR	20	-
	PRATIO	0.778	-
	PNFI	0.28	-
	PCFI	0.288	-
	NCP	393.105	-
	AIC	468.105	-
	BCC	469.538	-
	BIC	543.409	-
	CAIC	563.409	-
	ECVI	1.472	-
	MECVI	1.477	-
	HOELTER (0.05)	37	-
	HOELTER (0.01)	43	-

Source: Field survey, 2022.

Nexus between food insecurity and resilience capacity

The integrative framework of households' food insecurity and resilience capacity showed that majority of the households fell in the best-case category as evident by the density of the dotted points in second bottom quadrant in Figure 11. Besides, self-made category is the next populated category, followed by prodigal-case category while worst-case category had very few households.

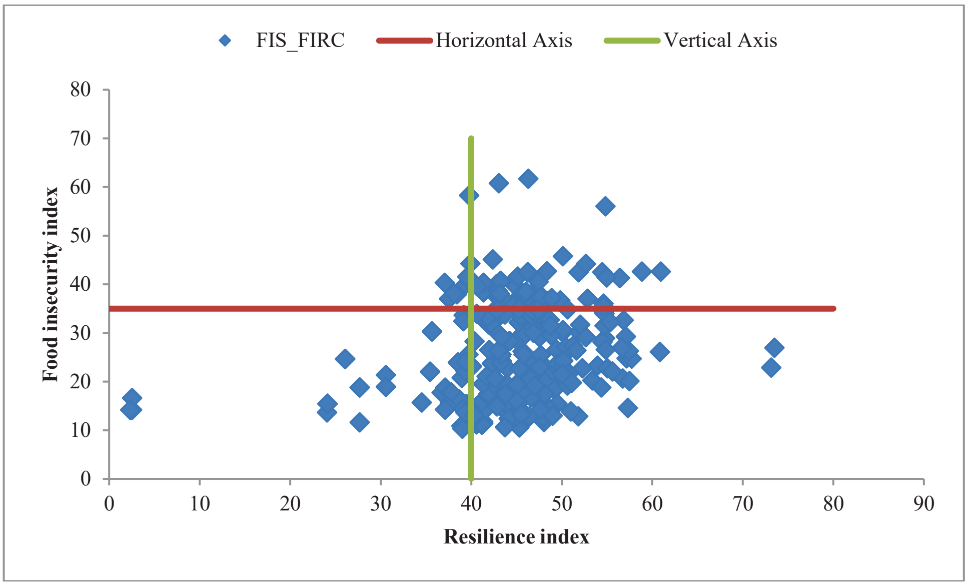


Fig. 11. Nexus of food insecurity and resilience capacity

Source: Field survey, 2022.

Food Coping Strategies Adopted by Households

To identify the common food coping strategies, of the twelve adopted food coping strategy components, the varimax rotation retained only three interpretable components as evident by their respective Eigen value that are greater than unity (Table 6). Besides, these retained factors account for 60.57% of the total variation of the adopted food coping strategies subjected to analysis. Noteworthy, the sampling was established to be adequate as evident by the KMO measure that possessed a good value of 0.870 that is above the satisfactory threshold value of 0.50 recommended by Keiser (1974); Field (2005); Sadiq et al.(2017); Sadiq et al.(2018c&d). In addition, the rotation matrix (R-matrix) has a common. The R-matrix is not an identity matrix as evident by the plausibility of its Bartlett's sphericity test at less than 1% probability level. Nevertheless, each of these factors had internal consistency in its loadings as indicated by their respective Cronbach's Alpha tests that are above the threshold of 0.70 reported to be satisfactory for social science studies by Nunnally (1978); Nunnally and Bernstein (1994); Prunomo and Lee (2010); Sadiq et al.(2017); Sadiq et al.(2018c&d).

As rightly done by Bagheri and Fami (2016); Sadiq et al.(2017) and Sadiq et al.(2018c&d), factor loadings with values less than 0.40 in each of the extracted components were dropped and in labeling a component loaded with only two loadings, only the factor with the highest score is considered. Component 1, labeled "meal skipping (MS)", with 40.07% of total variance and loaded with seven factors showed households concern on income smoothening as a food coping measure. Component 2, labeled "eaten of inferior meals (IM)", with 11.67% of total variance proportion and loaded with three factors showed households concern on meal substitutions, thus smoothening their income. The duo of these components is aimed towards enjoying expanded expenditure on food commodities on continuum basis by the rural households. Component 3, labeled "consumption credit (CC)", loaded with two factors and accounted for 8.83% of the total variance showed households concern on the use of consumption credit as a measure to smoothen their consumption

Table 6. Coping strategies adopted by the rural households

Strategies	F1	F2	F3
Rely on less preferred and less expensive food (C1)		0.690	
Borrow food from a relative or friend (C2)	0.468	0.500	
Purchase food on credit (C3)			0.809
Consume seed stock for next season (C4)			0.638
Gather wild food, hunt, or harvest immature crops (C5)	0.798		
Send children to eat with neighbor/relative (C6)	0.776		
Send members of the household to beg (C7)	0.772		
Reduce the portion size at mealtimes (C8)	0.458	0.527	
Restrict consumption of adult for children to eat (C9)	0.745	0.447	
Reduced the number of meals eaten in a day (C10)	0.601	0.570	
Skip a complete day without eaten (C11)	0.827		
Sell of agricultural equipment/assets (C12)	0.559		
Eigen value	**4.808**	**1.400**	**1.059**
Variance %	**40.071**	**11.667**	**8.828**
Cronbach's Alpha	**0.872**	**0.423**	**0.388**
KMO		**0.870**	
Bartlett's Test		**1481.321 (0.00***)**	

Note: Measured on four scale continuum basis (frequently; occasionally; rarely & not used)

*** means significant at 1%

Source: Field survey, 2022.

Furthermore, structurally, it was established that IM and CC significantly influenced households' hunger resilience capacity (HRC) as evident by their respective parameter estimates that are plausible within 10% probability level (Table 7a and Figure 12). While CC increases the HRC, IM tends to decrease it and the possible reason may be that the substituted inferior foods are of poor diet quality, thus affecting their labour productivity. However, SM, an income smoothening measure, being insignificant on HRC may be associated to less dependency ratio in the households' composition. Therefore, a unit increase in IM and CC coping strategies will increase and decrease households' HRC by 0.151 and -0.104% respectively. The total effects of CC, IM and SM on HRC were 0.151, -0.104 and 0.062% respectively. Furthermore, HRC, a mediation factor, positively and significantly influenced short-term (dietary diversity-DDS) and mid-term (food consumption score- FSC) food securities but failed to have significant influence on long-term food security (FSS) and sustainable livelihood (LI). Nevertheless, HRC being a transitory situation might be the possible reason why its influence on the duo of long-term food security and sustainable livelihood were insignificant. The total effects of HRC on DDS, FCS, FSS and LI were 5.872, 47.524, 0.055 and 0.118% respectively (Table 7b). The model fit statistics confirmed that the structural model is best fit for the specified equation as indicated by its respective test statistics that are within the acceptable recommended thresholds (Table 7c). Generally, it can be inferred that hunger coping strategy has a transitory effect on the food security of the rural households in the study area.

Table 7a: Effects of coping strategy on food security and sustainable livelihood

Variable (→)		Estimate (US)	Estimate (S)	SE	CR	P-value	R^2
HRC	MS	0.062	0.113	0.044	1.415	0.157^{NS}	0.043
HRC	IM	-0.104	-0.145	0.056	-1.847	0.065*	
HRC	CC	0.151	0.098	0.083	1.814	0.070*	
C12	MS	1.000	0.438	-	-	-	0.192
C11	MS	1.773	0.818	0.229	7.734	***	0.670
C10	MS	2.084	0.678	0.288	7.243	***	0.460
C9	MS	2.804	0.819	0.363	7.736	***	0.671
C7	MS	1.471	0.723	0.198	7.422	***	0.523
C6	MS	1.668	0.757	0.221	7.545	***	0.574
C5	MS	1.738	0.745	0.232	7.500	***	0.554
C8	IM	1.000	0.278	-	-	-	0.077
C2	IM	4.622	1.312	4.379	1.055	0.291^{NS}	1.720
C1	IM	0.467	0.138	0.158	2.952	0.003**	0.019
C4	CC	1.000	0.115	-	-	-	0.013
C3	CC	17.594	2.172	94.815	0.186	0.853^{NS}	4.718
LI	HRC	0.118	0.117	0.079	1.499	0.134^{NS}	0.014
FSS	HRC	0.055	0.117	0.037	1.497	0.135^{NS}	0.014
FSC	HRC	47.524	0.871	20.262	2.345	0.019**	0.758
DDS	HRC	5.872	0.699	2.426	2.421	0.015**	0.489
INC	HRC	1.000	0.152	-	-	-	0.023
Variance							
MS	-	0.092	-	0.023	3.903	***	-
IM	-	0.054	-	0.054	1.000	0.317^{NS}	-
CC	-	0.012	-	0.063	0.184	0.854^{NS}	-
e13	-	0.027	-	0.022	1.217	0.224^{NS}	-
e1	-	0.386	-	0.031	12.271	***	-
e2	-	0.142	-	0.015	9.652	***	-
e3	-	0.467	-	0.041	11.382	***	-
e4	-	0.353	-	0.037	9.636	***	-
e5	-	0.181	-	0.016	11.025	***	-
e6	-	0.189	-	0.018	10.658	***	-
e7	-	0.222	-	0.021	10.806	***	-
e8	-	0.641	-	0.071	9.062	***	-
e9	-	-0.479	-	1.055	-0.454	0.650^{NS}	-
e10	-	0.603	-	0.049	12.344	***	-
e11	-	0.863	-	0.092	9.358	***	-
e12	-	-2.819	-	19.142	-0.147	0.883^{NS}	-
e14	-	0.028	-	0.002	12.567	***	-
e15	-	0.006	-	0.000	12.567	***	-
e16	-	19.932	-	10.569	1.886	0.059*	-
e17	-	0.998	-	0.178	5.593	***	-
e18	-	1.174	-	0.094	12.536	***	-

Note: ***, **, * & NS mean significant at 1, 5, 10% and non-significant respectively; US=Unstandardized; S=Standardized; SE=Standard error: CR=Critical ratio; P=Probability; R^2=Squared multiple correlation; →=relationship; e= error term; and, INC= Income.

Source: Field survey, 2022.

Table 7b: Direct, indirect and total effects of latent and mediating variables on food security and sustainable livelihood

Variable	CC	IM	MS	HRC	CC	IM	MS	HRC
	Unstandardized				Standardized			
Direct effect								
HRC	.151	-.104	.062	.000	.098	-.145	.113	.000
INC	.000	.000	.000	1.000	.000	.000	.000	.152
DDS	.000	.000	.000	5.872	.000	.000	.000	.699
FSC	.000	.000	.000	47.524	.000	.000	.000	.871
FSS	.000	.000	.000	.055	.000	.000	.000	.117
LI	.000	.000	.000	.118	.000	.000	.000	.117
C3	17.594	.000	.000	.000	2.172	.000	.000	.000
C4	1.000	.000	.000	.000	.115	.000	.000	.000
C1	.000	.467	.000	.000	.000	.138	.000	.000
C2	.000	4.622	.000	.000	.000	1.312	.000	.000
C8	.000	1.000	.000	.000	.000	.278	.000	.000
C5	.000	.000	1.738	.000	.000	.000	.745	.000
C6	.000	.000	1.668	.000	.000	.000	.757	.000
C7	.000	.000	1.471	.000	.000	.000	.723	.000
C9	.000	.000	2.804	.000	.000	.000	.819	.000
C10	.000	.000	2.084	.000	.000	.000	.678	.000
C11	.000	.000	1.773	.000	.000	.000	.818	.000
C12	.000	.000	1.000	.000	.000	.000	.438	.000
Indirect effect								
HRC	.000	.000	.000	.000	.000	.000	.000	.000
INC	.151	-.104	.062	.000	.015	-.022	.017	.000
DDS	.888	-.611	.365	.000	.068	-.101	.079	.000
FSC	7.187	-4.945	2.957	.000	.085	-.126	.098	.000
FSS	.008	-.006	.003	.000	.011	-.017	.013	.000
LI	.018	-.012	.007	.000	.011	-.017	.013	.000
C3	.000	.000	.000	.000	.000	.000	.000	.000
C4	.000	.000	.000	.000	.000	.000	.000	.000
C1	.000	.000	.000	.000	.000	.000	.000	.000
C2	.000	.000	.000	.000	.000	.000	.000	.000
C8	.000	.000	.000	.000	.000	.000	.000	.000
C5	.000	.000	.000	.000	.000	.000	.000	.000
C6	.000	.000	.000	.000	.000	.000	.000	.000
C7	.000	.000	.000	.000	.000	.000	.000	.000
C9	.000	.000	.000	.000	.000	.000	.000	.000
C10	.000	.000	.000	.000	.000	.000	.000	.000
C11	.000	.000	.000	.000	.000	.000	.000	.000
C12	.000	.000	.000	.000	.000	.000	.000	.000
Total effect								
HRC	.151	-.104	.062	.000	.098	-.145	.113	.000
INC	.151	-.104	.062	1.000	.015	-.022	.017	.152
DDS	.888	-.611	.365	5.872	.068	-.101	.079	.699
FSC	7.187	-4.945	2.957	47.524	.085	-.126	.098	.871
FSS	.008	-.006	.003	.055	.011	-.017	.013	.117
LI	.018	-.012	.007	.118	.011	-.017	.013	.117
C3	17.594	.000	.000	.000	2.172	.000	.000	.000
C4	1.000	.000	.000	.000	.115	.000	.000	.000
C1	.000	.467	.000	.000	.000	.138	.000	.000
C2	.000	4.622	.000	.000	.000	1.312	.000	.000
C8	.000	1.000	.000	.000	.000	.278	.000	.000
C5	.000	.000	1.738	.000	.000	.000	.745	.000
C6	.000	.000	1.668	.000	.000	.000	.757	.000
C7	.000	.000	1.471	.000	.000	.000	.723	.000
C9	.000	.000	2.804	.000	.000	.000	.819	.000
C10	.000	.000	2.084	.000	.000	.000	.678	.000
C11	.000	.000	1.773	.000	.000	.000	.818	.000
C12	.000	.000	1.000	.000	.000	.000	.438	.000

Source: Field survey, 2022.

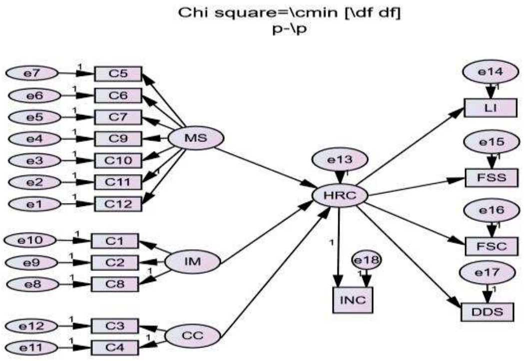


Fig. 12. Structural modeling of hunger resilience capacity (HRC)
Source: Computer print-out, 2022

Table 7c. Model fit summary

Category name	Index name	Obtained	Recommended
Absolute fit	CMIN	603.885	-
	DF	116	-
	P	0.00	p<=0.05
	RMSEA	0.015	< 0.08
	RMR	0.014	<0.02
	GFI	0.924	> 0.90
Incremental fit	AGFI	0.968	> 0.90
	NFI	0.973	> 0.90
	RFI	0.917	> 0.90
	TLI	0.966	> 0.90
	CFI	0.915	> 0.90
	IFI	0.919	> 0.90
	PGFI	0.925	> 0.90
	FMIN	1.899	> 0.90
Parsimonious fit	CMIN/DF	4.206	< 5.0
Others	NPAR	37	-
	PRATIO	0.853	-
	PNFI	0.574	-
	PCFI	0.61	-
	NCP	487.885	-
	AIC	677.885	-
	BCC	682.325	-
	BIC	817.197	-
	CAIC	854.197	-
	ECVI	2.132	-
	MECVI	2.146	-
	HOELTER (0.05)	75	-
	HOELTER (0.01)	82	-

Source: Field survey, 2022.

Conclusions and recommendations

Empirically, the findings established that the study area is challenged with food insecurity in the short and long terms while it was in the comfort zone of food security in the mid-term. However, poor food utilization and stability were the bane of food insecurity in the long-run. Generally, it was inferred that the rural economy of the study area is obviously in a battle to keep the body and soul together. Furthermore, poor food insecurity resilience capacity of majority of the households due to poor adaptive capacity was unmasked as the prime factor behind the exacerbated state of food insecurity. More so, food insecurity resilience capacity significantly influenced food security across the term periods and sustainable livelihood while households' hunger resilience capacity is only sustainable on short-term food security. Nevertheless, the empirical evidence showed that the rural households adopted income and consumption smoothening as coping strategies for short-term food insecurity. Therefore, to adjust the state of poor food stability and utilization, the study advises the rural households to adopt safe and eco-friendly improved indigenous food technologies that will minimize waste, thereby enhancing food shelf-life and value addition. By so doing, it will go a long way to address the alarming state of food insecurity which is a portend threat to the achievement of sustainable development goals of zero hunger by 2030.

References

Abebe, G. (2020). Cash-for-work and food-for-work programmes' role in household resilience to food insecurity in southern Ethiopia. *Development in Practice*, 30(8), 1068-1081.

Ado, A.M., Savadogo, P., Abdoul-Azize, H.T. (2022). Livelihood strategies and household resilience to food insecurity: Insight from a farming community in Aguie district of Niger. In: Rethinking Food System Transformation (pp. 97-111). Cham: Springer Nature Switzerland.

Agwu, G.A. (2023). The Boko Haram conflict and food insecurity: Does resilience capacity matter? *Journal of African Economies*, 32(4), 352-382.

Alhassan, H. (2020). Farm households' flood adaptation practices, resilience and food security in the Upper East region, Ghana. Heliyon, 6(6).

Alinovi, L., Mane, E., Romano, D. (2008). Towards the measurement of household resilience to food insecurity: applying a model to Palestinian household data. In: Deriving Food Security Information from National Household Budget Surveys. Experiences, Achievement, Challenges (pp. 137-152). Food and Agricultural Organization of the United Nations.

Anand, S., Sen, A. (1997). Concepts of human development and poverty: A Multidimensional perspective. In: Poverty and Human Development. Human Development Papers. Human Development Report Office. The United Nations Development Programme, NY, USA.

Ansah, I.G.K., Gardebroek, C., Ihle, R. (2019). Resilience and household food security: a review of concepts, methodological approaches and empirical evidence. *Food Security*, 11(6), 1187-1203.

Ansah, I.G.K., Kotu, B.H., Manda, J., Muthoni, F., Azzarri, C. (2023). Mediation and moderation roles of resilience capacity in the shock–food-security nexus in northern Ghana. *Ecological Economics*, 211, 107894.

Atara, A., Tolossa, D., Denu, B. (2020). Analysis of rural households' resilience to food insecurity: Does livelihood systems/choice/matter? The case of Boricha woreda of sidama zone in southern Ethiopia. *Environmental Development*, 35, 100530.

Bagheri, A., Fami, H.S.(2016). Potato growers' risk perception: A case study in Ardabil Province of Iran. *Journal of Agricultural Science and Technology*, 18, 55-65

Bahta, Y.T. (2022). Nexus between coping strategies and households' agricultural drought resilience to food insecurity in South Africa. *Land*, 11(6), 893.

Béné, C. (2020). Resilience of local food systems and links to food security-A review of some important concepts in the context of COVID-19 and other shocks. *Food Security*, 12(4), 805-822.

Beyene, F., Senapathy, M., Bojago, E., Tadiwos, T. (2023). Rural household resilience to food insecurity and its determinants: Damot Pulasa district, Southern Ethiopia. *Journal of Agriculture and Food Research*, 11, 100500.

Calloway, E.E., Carpenter, L.R., Gargano, T., Sharp, J.L., Yaroch, A.L. (2022). Development of three new multidimensional measures to assess household food insecurity resilience in the United States. *Frontiers in Public Health,* 10, 1048501.

Chamdimba, O.Y., Ortmann, G.F., Wale, E. (2021). Resilience to shocks and food insecurity: Determinants, and the impact of smallholder jatropha curcas cultivation in Southern Malawi. *African Journal of Science, Technology, Innovation and Development*, 13(5), 619-633.

d'Errico, M., Pinay, J., Jumbe, E., Luu, A.H. (2023). Drivers and stressors of resilience to food insecurity: evidence from 35 countries. *Food Security*, 1-23.

Dhraief, M. Z., Dhehibi, B., Daly Hassen, H., Zlaoui, M., Khatoui, C., Jemni, S., ... & Rekik, M. (2019). Livelihoods strategies and household resilience to food insecurity: A case study from rural Tunisia. Sustainability, 11(3), 907.

Egamberdiev, B., Bobojonov, I., Kuhn, L., & Glauben, T. (2023). Household resilience capacity and food security: evidence from Kyrgyzstan. Food Security, 15(4), 1161-1183.

FAO (2016). Resilience Measurement and Analysis-II (RIMA-II). Retrieved from www.fao.org/publication.

FAO(2015). RIMA-II: Moving Forward the Development of the Resilience Index Measurement and Analysis Model. Retrieved from www.fao.org/resilience

Field, A.P. (2005). Is the meta-analysis of correlation coefficients accurate when population correlations vary? *Psychological Methods*, 10(4), 444.

Haile, D., Seyoum, A., Azmeraw, A. (2022). Food and nutrition security impacts of resilience capacity: Evidence from rural Ethiopia. *Journal of Agriculture and Food Research*, 8, 100305.

Ha-Mim, N.M., Hossain, M.Z., Rahaman, K.R., Mallick, B. (2020). Exploring vulnerability–resilience–livelihood nexus in the face of climate change: A multi-criteria analysis for Mongla, Bangladesh. *Sustainability*, 12(17), 7054.

Kaiser, H.F. (1974). An index of factorial simplicity. *Psychometrika*, 39(1), 31-36.

Lascano Galarza, M.X. (2020). Resilience to food insecurity: Theory and empirical evidence from international food assistance in Malawi. *Journal of Agricultural Economics*, 71(3), 936-961.

Mathye, R., Gerickle, G. (2019). Caregivers' perceptions of household hunger and adequacy of dietary intake in a resource limited community in the Bronkhorstspruit district (Gauteng). *African Journal of Food, Agriculture, Nutrition and Development*, 19(3), 14541-14554.

Melketo, T., Schmidt, M., Bonatti, M., Sieber, S., Müller, K., Lana, M. (2021). Determinants of pastoral household resilience to food insecurity in Afar region, northeast Ethiopia. *Journal of Arid Environments*, 188, 104454.

Merchant, E.V., Fatima, T., Fatima, A., Maiyo, N., Mutuku, V., Keino, S., ... & Downs, S. M. (2022). The influence of food environments on food Security resilience during the COVID-19 pandemic: an examination of urban and rural difference in Kenya. *Nutrients*, 14(14), 2939.

Meyer, M.A. (2020). The role of resilience in food system studies in low-and middle-income countries. *Global Food Security*, 24, 100356.

Mkupete, M.J., Donath, L.T., Mugizi, F.M. (2023). Household resilience to food and nutrition insecurity during COVID-19 in Tanzania. *Geojournal*, 88(2), 1721-1735.

Murendo, C., Aziz, T., Tirivanhu, D., Mapfungautsi, R., Stack, J., Mutambara, S., ... & Mafuratidze, C. (2021). Dietary diversity and food coping strategies in Zimbabwe: do resilience and food insecurity status matter? *Ecology of Food and Nutrition*, 60(1), 116-136.

Myeki, V.A., Bahta, Y.T. (2021). Determinants of smallholder livestock farmers' household resilience to food insecurity in South Africa. *Climate*, 9(7), 117.

Nahid, N., Lashgarara, F., Farajolah Hosseini, S.J., Mirdamadi, S.M., Rezaei-Moghaddam, K. (2021). Determining the resilience of rural households to food insecurity during drought conditions in Fars province, Iran. *Sustainability*, 13(15), 8384.

National Population Commission (NPC) (2021). 2006 Population and Housing Census: Population Distribution by Sex, State, LGA and Senatorial District (Priority Table Volume III). Abuja: National Population Commission, Abuja, Nigeria.

Negesse, A., Woyraw, W., Temesgen, H., Teka, Y., Yismaw, L., Akalu, T.Y., ... & Desalegn, B.B. (2022). Spatial exploration of non-resilience to food insecurity, its association with COVID-19 and household coping strategies in East Gojjam districts, Northwest Ethiopia, 2020. Scientific Reports, 12(1), 15511.

Nunnally, J., Bernstein, I. (1994). Psychometric Theory 3rd Edition (MacGraw-Hill, New York).

Nunnaly, J.C. (1978). Psychometric Theory, 2nd Edition, McGraw Hill, New York.

Ouoba, Y., Sawadogo, N. (2022). Food security, poverty and household resilience to COVID-19 in Burkina Faso: Evidence from urban small traders' households. *World Development Perspectives*, 25, 100387.

Sadiq, M.S., Sani, B.S. (2022). Lıvelıhood status of paddy rıce agro-processors that benefitted from mıcrofınance credıt in Jıgawa State of Nıgerıa. *Bozok Journal of Agriculture and Natural Sciences*, 1(2), 71-94.

Sadiq, M.S., Singh, I.P., Ahmad, M.M., Lawal, M. (2018a). Drivers of poverty status among sugarcane farmers in Kwara State of Nigeria. *Academic Studies-National Journal of Jyoti Research Academy*, 12(2), 96-103.

Sadiq, M.S., Singh, I.P., Ahmad, M.M., Lawal, M., Sadiq, U.N., Kabeer, Y.M. (2018b). X-raying poverty dynamics of homestead broiler entrepreneurs in Niger State of Nigeria. *Journal of Animal Production Research*, 30(2), 204-214.

Sadiq, M.S., Singh, I.P., Ahmad, M.M., Lawal, M., Kamaldeen, N., Sani, T.P. (2018c).Determining the perceived constraints affecting cassava farmers in Kwara State of Nigeria. *FUDMA Journal of Agriculture and Agricultural Technology*, 4(2), 235-247

Sadiq, M.S., Singh, I.P., Ahmad, M.M., Lawal, M., Shehu, H.O., Sani, T.P., Yusuf, T.L. (2018d). Perceived constraints affecting homestead fish farming in Kogi State, Nigeria. *FUDMA Journal of Agriculture and Agricultural Technology*, 4(2), 255-266

Sadiq, M.S., Singh, I.P., Isah, M.A., Greima, I.J., Umar, S.M. (2017). Strategy of minimizing the cost of cultivation vis-à-vis boosting farm income of small-holder maize farmers in Niger State of Nigeria using Efficiency Measurement System (EMS). *Indian Journal of Economics and Development*, 17(2a), 722-728

Sunday, N., Kahunde, R., Atwine, B., Adelaja, A., George, J. (2023). How specific resilience pillars mitigate the impact of drought on food security: Evidence from Uganda. *Food Security*, 15(1), 111-131.

For citation:

Sadiq M.S., Singh I.P., Ahmad M.M., Bala M.U. (2023). Food Insecurity Resilience Capacity of Rural Households in the Face of Induced-Weather Extremities in Bauchi State of Nigeria. *Problems of World Agriculture*, 23(3), 20-44; DOI: 10.22630/PRS.2023.23.3.10

Scientific Journal Warsaw University of Life Sciences – SGGW
Problems of World Agriculture volume 23(XXXVIII), number 3, 2023: 45-60
DOI: 10.22630/PRS.2023.23.3.11

Sunday B. Akpan[1✉], Edet J. Udoh[2], Veronica S. Nkanta[3]
[1] Akwa Ibom State University, Nigeria
[2,3] University of Uyo, Nigeria

Agricultural Credit Policy and Livestock Development in Nigeria

Abstract. This research aimed to provide empirical information on the relationship between the livestock production index and the credit policy environment in Nigeria. Time series data were used, and an autoregressive distributed lag (ARDL) bound test approach was adopted to establish the presence of co-integration among series. The estimated long and short run models showed stability, best quality, efficiency and unbiased. The findings showed that in the long run, total credit to the agricultural sector from commercial banks and domestic credit to the private sector both had significant positive influence on livestock production, while agricultural credit guarantee scheme loans to livestock units exhibited a negative impact. In the short run, agricultural credit guarantee scheme loans to livestock, lending interest rate, and domestic credit to the private sector negatively relate to livestock production. However, the commercial banks' total credit to the agricultural sector showed a positive effect on livestock production in the short run. The implication of the findings indicates a need to increase total commercial credit to the agricultural sector and domestic credit to the private sector, to reassess the agricultural credit guarantee scheme, and to lower the lending interest rate for agricultural credit – these as a means for increasing livestock production in the country.

Keywords: livestock, credit, agricultural policies, economic growth, Nigeria

JEL Classification: Q14, Q18

Introduction

Agricultural credit is recognized as an essential tool for promoting agricultural production, especially among poor rural farmers who constitute the bulk of farming populations in most developing countries (Idiong et al., 2010; Akpan et al., 2012; Jeiyol et al., 2013; Akpan et al., 2020). Access to agricultural credit has been positively linked to agricultural productivity in several studies in Nigeria (Akpan et al., 2013; Awotide et al., 2015; Abu, et al., 2017; Adewale et al., 2022). Despite this positive correlation, several empirical studies have revealed cases of credit insufficiency among rural farmers in Nigeria (Adebayo &Adeola, 2008; Ololade &Olagunju, 2013; Assogba et al., 2017; Asom et al., 2023). Credit is regarded as an important instrument for generating income, mobilizing resources, and creating a competitive production and economic environment (Akpan et al., 2012; Akpan et al., 2013; Essien and Arene 2014). Credit is critical since most farmers are resource-poor, and agricultural production and processing are time-bound. Beck and

[1] Department of Agricultural Economics and Extension, Akwa Ibom state University, Ikot Akpaden, Mkpat Enin, Akwa Ibom State, Nigeria; e-mail: sundayakpan@aksu.edu.ng; https://orcid.org/0000-0002-0458-028X; Corresponding author
[2] Department of Agricultural Economics and Extension, University of Uyo, Nigeria; https://orcid.org/0000-0002-4550-4320
[3] Department of Agricultural Economics and Extension, University of Uyo, Nigeria; https://orcid.org/0000-0001-7035-7978

Demirguc-Kunt, (2006), noted that the provision of credit enhances the welfare of the vulnerable through income smoothening. According to Jeiyol et al., (2013) and Akpan et al., (2013), credit is an essential ingredient of sustainable agricultural production and processing; as such its accessibility and demand are prerequisites for attaining the national goal of reducing rural poverty, creating sustainable employment, and ensuring self-sufficiency in food production in the country.

In response to these assertions, the Federal Government of Nigeria has in the past initiated various agricultural credit policies and programs to improve agricultural production by providing cheap and subsidized financial resources to farmers at a concessional interest rate (Akpan et al., 2012). For example, community banks were introduced into the country's financial landscape in 1990 to provide banking and financial services to the rural economy and micro-enterprises in urban centers. In 1996, the Central Bank of Nigeria issued guidelines for sectoral concessional lending to agriculture (Manyong et al., 2005). In 2009, the Central Bank of Nigeria (CBN), in collaboration with the Federal Ministry of Agriculture and Water Resources (FMAWR), established the Commercial Agriculture Credit Scheme (CACS) to provide finance for agricultural processing, storage and marketing (Olomola & Yaro, 2015). In addition, other credit policies introduced by the Federal government include the Nigeria Incentive-Based Risk Sharing System for Agricultural Lending (NIRSAL) launched in 2011, and the Micro, Small, and Medium Enterprises Development Fund (MSMEDF) launched in 2013 (Salisu and Alamu, 2023). Furthermore, the manipulation of the macroeconomic environment through tools such as exchange rate policy, lending interest rate policy and other monetary and fiscal policy measures have been deliberately used to stimulate growth in the real sector of the economy (CBN, 2022).

Given the incentives provided by the government to farmers and agribusinesses in the country to improve their performance (Akpan et al., 2012), the existence of a dualistic credit market structure that provides flexibility in credit access and demand, as well as the spread of an effective market system, many researchers have reported that the abysmal performance of the agricultural sector is due to insufficient credit to farmers and agribusinesses in the country (Essien &Arene, 2014; Essien et al., 2016; Assogba et al., 2017; Asom et al., 2023). As reported by Essien et al. (2016), Akpan et al. (2016) and Akpan et al. (2019), the low performance of farmers and small agribusinesses would likely increase poverty, hunger, unemployment, and poor living standards for many rural families. Likewise, Adebayo & Adeola, (2008) and Adewale et al., (2022) stated that credit is a good means of acquiring facilities to improve agricultural production to increase participants' income and improve living standards.

In light of the crucial role of agricultural credit in promoting agricultural production, there is a need to establish the empirical connection between the credit policy environment and agricultural production indicators in the country. The livestock subsector is one of the components of the agricultural sector that has played a significant role in rural livelihoods and in the economy of developing countries (Akpan, 2022). Its rich and complex value chain is a source of income and employment for many rural households. The subsector serves as an important capital reserve and safety net for many poor rural agricultural households. Livestock plays a significant role in rural household dynamics and family social status. The subunit also contributes to global protein and energy supplies (Herrero, et al., 2013; Varijakshapanicker et al., 2019; Hennessy et al., 2021; Pexas, et al., 2023). In mixed and integrated farming systems, complementary relationships between livestock and crops have contributed to both the intensification and diversification of farmers' income streams (Thornton et al., 2002). Given these myriad contributions of the livestock subsector to the Nigerian economy, there is an overwhelming need to examine its relationship with the country's credit policy environment. Despite the implementation of several credit policies in the country, Nigerians' protein intake remains well below the WHO recommended standard (Akpan &Udo, 2021; Akpan &Nkanta, 2022; Akpan, 2022). According to Hatab et al. (2019), several development policies and programs for the livestock subsector in sub-Saharan African economies tend to contribute less to livestock production, productivity, poverty reduction, and food security of rural households. According to Oyelade (2019), one of the reasons for the decline in the agricultural sector's contribution to GDP is the lack of access to credit from commercial banks. These claims need to be verified in Nigeria, particularly given the high levels of poverty, malnutrition and increasing food insecurity in the country.

Several authors in developing countries have recognized the importance of the relationship between the credit policy environment and agricultural production and have tried to establish empirical facts. For example, Chisasa and Makina (2013) reported that a 1% increase in credit would stimulate about 0.6% upsurge in agricultural production in South Africa. Khan et al. (2007) claimed in Pakistan that loans disbursed to livestock farmers were grossly misused by the majority of beneficiaries and did not improve their socio-economic characteristics. Later, Khan et al., (2018) found credit as a stimulant to livestock production in the Pakistan region. In Ethiopia, Duguma and Debsu (2019) identified the importance of credit services to livestock production. Similarly, Abedullah et al. (2009); Khan et al. (2018) in Pakistan and Adewale et al. (2022) in Nigeria found a positive relationship between agricultural credit and livestock production and farmers' income. In Nigeria, Olagunju and Babatunde (2011) found a significant positive relationship between the productivity of poultry farmers and credit acquisition. Elsewhere, Rahman et al. (2011) found a strong direct relationship between agricultural credit and animal production (milk, meat, and eggs) in Bangladesh. Also in Nigeria, Kuye (2013) found that microcredit makes a positive contribution to livestock production in the southern region of the country. Using time series, Zakaree (2014) postulated that the Agricultural Credit Guarantee Scheme Fund (ACGSF) operating in Nigeria has a negative and statistically significant impact on domestic food production. In Ethiopia, Shiferaw et al. (2015) identified the positive role of credit for livestock production. When Orok and Ayim (2017) expanded their study on ACGSF in Nigeria, they claimed that the ACGSF has a greater impact on the crop production sub-sector than on the livestock and fisheries sub-sectors. Also, Abu (2017) and Reuben et al. (2020) reported that ACGSF increased the productivity of the livestock subsector from 1981 to 2014. Udoka et al. (2016), Asekome and Ikojie, (2018),and Iliyasu, (2019), found that the lending interest rates impact negatively on agricultural investment in Nigeria. Carrer et al. (2020) highlighted the importance of rural credit policies for the implementation of integrated cropping and livestock production systems in Brazil. Umboh et al. (2021) found that agricultural credit combined with other agricultural inputs increases the productivity of livestock farmers. Salisu and Alamu (2023) asserted that commercial bank lending to agriculture, along with interest rates, has a positive and statistically significant effect on agricultural output in Nigeria.

From the literature reviewed, it appears that the focus of this research in Nigeria has not been adequately addressed. Furthermore, a lot has happened in Nigeria's macroeconomic environment over the last two decades and the country has sunk even deeper into the scourge of poverty and urgently needs proactive policy interventions based on current realities. Therefore, there is a need to update the available information on the relationship between the production of the livestock subsector and the credit environment in Nigeria. In addition, most of the studies reviewed considered a single source of credit for livestock farmers, whereas there are multiple sources with their specific issues. This study differs from other related studies in that multiple sources of credit and enhancers of farm credit (lending rate) are incorporated in the model to isolate their respective impact on livestock production. The findings would have wider implications on the growth of the livestock subsector in developing countries, since agricultural financing is a huge problem in this region. The study therefore specifically sought to establish the empirical relationship between the agricultural credit policy environment and the growth of livestock sub-sectors in Nigeria.

Research methodology

Study area

Nigeria is rich in agricultural resources and over 60 percent of the population is involved in the production of staple foods such as cassava, maize, rice, yams, various beans and pulses, sorghum, ginger, onions, tomatoes, melons, and vegetables etc., (FAO, 2023; Federal Ministry of Agriculture and Food Security [FMAFS], 2023). In Nigeria animal production such as poultry, goats, sheep, pigs and cattle flourished in all regions of the country (FMAFS, 2023). The most important cash crops are cocoa, cotton, peanuts, palm oil and rubber (Federal Ministry of Environment, 2021).

Data source

The study used secondary data from the World Bank, Central Bank of Nigeria and Food and Agriculture Organization (FAO). The data covered the period from 1991 to 2021. The timespan chosen was based on data availability.

Model specification / analytical technique

The contribution of the agricultural credit policy environment to the growth of the livestock subsector (proxy by livestock production index) in Nigeria has been implicitly stated in a Cobb-Douglas form as shown in Equation 1. The specification of the model followed the production theory. Acquired credit is assumed to be used for acquired factors of production such as labor, capital, and land etc. According to Omolade and Adepoju (2019), agricultural credit is directly related to agricultural production factors. Implicitly, agricultural production is a function of agricultural credit. The estimated coefficients of the given model represent the elasticity. However, we consider different categories of credit that are directly or indirectly available to the agricultural sector. In the model, each credit variable was transformed by weighting to reduce the tendency for multicollinearity.

$$LISP\_t = f(ACGL\_t, CAGR\_t, LENR\_t, DCPS\_t) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:
$LISP_t$ = Livestock gross production index (2014-2016 = 100) (%);

$ACGL_t$ = Guarantee loan for livestock sub-sector/total fund guarantee by Agricultural Credit Guarantee Fund Scheme (%);
$CAGR_t$= Total credit to the agricultural sector from the commercial bank/economy GDP (%);
$LENR_t$ = National lending rate (%);
$DCPS_t$ = Domestic credit to private sector (% of GDP).

The explanatory variables represent independent credit policy instruments implemented by the Nigerian government over the years. For example, the Agricultural Credit Guarantee Fund was established to guarantee funds/credit to farmers with the Central Bank of Nigeria acting as the sole guarantor (ACGLt) (Umoren et al., 2016 and Umoren et al., 2018). Furthermore, the Federal Government of Nigeria has over the years required commercial banks to disburse a certain proportion of their total loans and advances to the agricultural sector (CAGRt). Additionally, the Central Bank of Nigeria has maintained a market-regulated lending rate in the country to moderate the volume of credit in the economy (LENRt). In addition, the central government has introduced a credit policy that incentivizes the financial sector to stimulate private investment in the real sector of the economy (DCPSt).

The relationship between the agricultural credit environment and livestock growth

The Autoregressive Distributed Lag (ARDL) model was estimated to determine the relationship between livestock growth and variables representing the agricultural credit environment or agricultural credit policy. The ARDL-bound test developed by Pesaran and Shin (1999) and Pesaran et al., (2001) was used to confirm the presence of cointegration among series. After confirming cointegration, the short- and long-run models of livestock growth were estimated. The ARDL-bound model has some advantages compared to the two-stage method of Engle and Granger (1987) and the cointegration method developed by Johansen and Juselius (1990). The ARDL-bound test method is used to handle series with mixed stationary problems (i.e. a mixture of 1(0) and 1(1)). Therefore, the assumption that all series must be integrated in the same order is relaxed. However, ARDL can also be applied to series that are stationary at the level or the first difference. The next advantage is that ARDL test is relatively more efficient for small and finite sample data sizes. The method provided unbiased and sufficient estimates of the long-run model (Harris &Sollis, 2003). The bounds test is a simple technique because, unlike other multivariate co-integration methods, it allows the co-integration relationship to be estimated by OLS once the lag order of the model is identified.

The ARDL model for Equation 1 in logarithm form is expressed as follows in Equation 2:

$$\Delta LISP_t = \beta_0 + \beta_1 \sum_{i=1}^{n_1} \Delta LISP_{t-i} + \beta_2 \sum_{i=1}^{n_2} \Delta ACGL_{t-i} + \beta_3 \sum_{i=1}^{n_3} \Delta CAGR_{t-i} + \beta_4 \sum_{i=1}^{n_4} \Delta LENR_{t-i} + \beta_5 \sum_{i=1}^{n_5} \Delta DCPS_{t-i} + \delta_1 LISP_{t-i} + \delta_2 ACGL_{t-i} + \delta_3 CAGR_{t-i} + \delta_4 LENR_{t-i} + \delta_5 DCPS_{t-i} + U_t \quad \ldots\ldots\ldots(2)$$

When using ARDL, the dependent variable is assumed to be a vector, and this implies that Equation 2 is also applied to the remaining variables specified in Equation 1. The coefficients from β1 to β5 represent the short-run coefficients, while the coefficients from δ1 to δ5 represent the long-run coefficients of the ARDL model. In addition, β0 is the drift component, n is the maximum lag length, and Ut is the stochastic error term. The bounded F-statistic test was used to verify the presence of a stable, long-term relationship between variables in the model. For instance, if the calculated bound F-statistic in Equation 2 is greater than the corresponding upper critical limits of one of the conventional probability levels defined at 1%, 5%, or 10%, the null hypothesis is rejected, meaning the existence of co-integration relationship. The tested hypothesis is stated as follows:

H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$ (There is no cointegration);

H_α: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$

However, if the value of the F-statistic is below the lower limits, the null hypothesis cannot be rejected, indicating the absence of co-integration. Furthermore, if the F-statistic value is within or between the lower and upper bounds, the result is considered inconclusive (Pesaran et al., 2001). If the bound test shows evidence of co-integration between variables, the long- and short-run models (an error correction model (ECM)) are specified. Using the equation of interest to us, the long-term and short-term models used in the study are given in Equations 3 and 4 respectively as follows:

The long run model:

$$LISP_t = \delta_0 + \delta_1 ACGL_t + \delta_2 CAGR_t + \delta_3 LENR_t + \delta_4 DCPS_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The short run model (ECM model):

$$\Delta LISP_t = \beta_0 + \beta_1 \sum_{i=1}^{q_1} \Delta LISP_{t-i} + \beta_2 \sum_{i=1}^{q_2} \Delta CAGR_{t-i} + \beta_3 \sum_{i=1}^{q_3} \Delta LENR_{t-i} + \beta_4 \sum_{i=1}^{q_4} \Delta DCPS_{t-i} + \beta_5 \sum_{i=1}^{n_5} \Delta ACGL_{t-i} + \emptyset ECM_{t-1} + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where Ø is the error correction term and it measures the speed of adjustment towards the long-run equilibrium, and the remaining coefficients provide the short-run dynamics. To test the performance of the estimated short run model, RESET test, Serial correlation, normality, and heteroscedasticity tests were conducted, whereas the cumulative sum (CUSUM) test was conducted to verify the stability nature of the model.

Results and discussion

Descriptive Statistics

The descriptive statistics of the variables used in the study are presented in Table 1. The coefficient of variability of the variables was less than 50%, implying minimal fluctuations in the specified variables. For example, the loan interest rate and livestock production index had a variability coefficient of 20.14% and 20.08%, respectively. The exponential growth rate values showed that the variables had a single-digit growth rate, implying minimal fluctuations within the study period. However, the Agricultural Guarantee Fund for Livestock Beneficiaries (ACGLt) and Loan Interest Rate (LENRt) had a negative annual exponential growth rate of -3.38% and -1.59%, respectively. This implies that these variables decrease as time increases.

Table 1. Descriptive statistics of variables used in the estimated models.

Variable	Min	Max	Mean	Std. deviation	CV	Skewness	Exponential growth rate (%)
LISP	50.040	103.820	84.472	16.962	0.20080	-0.83950	2.300
ACGL	4.942	20.721	12.279	4.8575	0.39560	0.29799	-3.380
CAGR	15.824	76.661	43.488	19.647	0.45178	0.19264	4.710
LENR	11.483	31.650	18.739	3.7735	0.20137	1.29410	-1.590
DCPS	5.241	19.626	10.446	3.4607	0.33129	0.88032	2.690

Source: Computed by the authors data from the FAO and World Bank.

Unit root test

The study used the ADF test developed by Dickey and Fuller (1979) and the ADF-GLS unit root test developed by Elliott, Rothenberg, and Stock (1996) to confirm the unit root of certain variables. The results for the ADF and ADF-GLS unit root tests are presented in Table 2. The results showed that one variable (LENRt) was stationary at the level, while others were stationary at the first difference for the ADF equation containing constant and trend. However, for the ADF-GLS equation with constant and trend, all specified variables were stationary at the first difference. Since the result gave a mixture of stationarity of the variables (i.e. 1(0) and 1(1)), it implies that the ARDL model can be used to test the co-integration in the given model.

Table 2. ADF and ADF-GLS unit root tests on variables used in the specified equation.

	ADF-GLS (with constant and trend)				**ADF (with constant and Trend)**			
	Lag	**Level**	**1st Diff.**	**Dec.**	**Lag**	**Level**	**1st Diff.**	**Dec.**
LISP	0	-1.4693	-5.6776***	1(1)	0	-1.2386	-6.1430***	1(1)
ACGL	0	-2.6993	-6.3978***	1(1)	0	-2.6004	-6.2492***	1(1)
CAGR	0	-2.9062	-6.1434***	1(1)	0	-2.9158	-5.9859***	1(1)
LENR	0	-3.2602**	-	1(1)	0	-3.1941	-5.7211***	1(1)
DCPS	0	-2.7776	-4.7252***	1(1)	0	-2.8146	-5.2125***	1(1)
		Critical values				**Critical values**		
1%		-3.7700	-3.7700		1%	-4.2967	-4.3098	
5%		-3.1900	-3.1900		5%	-3.5684	-3.5742	
10%		-2.8900	-2.8900		10%	-3.2184	-3.2217	

Note: ***, ** and * indicate 1%, 5% and 1% significance levels respectively. Note, variables are expressed in natural logarithms. Dec. means decision.

Source: computed by the authors.

The optimal lag length of the ARDL Model

Before estimating the ARDL model, the optimal lag length for the series were determined using the appropriate information criteria, i.e. Akaike information criterion (AIC), Schwarz-Bayes criterion (SBC) and Hannan-Quinn criterion. The corresponding lag length is shown in Table 3. The result showed that lag 4 is the best lag for the ARDL model. Figure 3 shows 20 computed ARDL models based on AIC criterion.

Table 3. Optimal lag length of series.

Lags	Loglik	P(LR)	AIC	BIC	HQC
1	54.41897	-	-3.724536	-3.434206	-3.640931
2	55.34065	0.17456	-3.718512	-3.379793	-3.620973
3	59.75960	0.00295	-3.981508	-3.594401	-3.870035
4	63.04103	0.01041	-4.157002*	-3.721507*	-4.031596*
5	63.86913	0.19812	-4.143779	-3.659896	-4.004438

Note: The asterisks below indicate the best (that is, minimized) values of the respective information criteria, AIC=Akaike criterion, BIC=Schwarz Bayesian criterion and HQC=Hannan-Quinn criterion.

Source: computed by the authors.

The ARDL bound test for cointegration

The bound test was used to confirm the presence of cointegration among specified variables in the model. The calculated F-statistic for the selected equation (6.4579) is shown in the upper part of Table 4. The result implies that the calculated F-test at the 1% probability level is greater than the tabulated upper bound of 4.37. This means that there is cointegration among the variables specified. The null hypothesis is rejected in this case.

The finding implies the following: For the equation of the gross production index for livestock, the long-run equilibrium or stability equation exists. Furthermore, the short-run or ECM model was generated to capture the short-run dynamics and identify the speed of adjustment in response to the deviation from the long-run equilibrium. After establishing cointegration for the specified variables, Table 5 shows the long-run coefficients or parameters for the ARDL model.

Table 4. ARDL bound test (restricted constant and no trend).

Equations	Lag	F-Statistic	Decision
F_{LISPt}(LISPt │ ACGLt, CAGRt, LENRt, DCPSt)	(1, 1, 2, 1, 4)	6.4570	Co-integration
	Critical Values at Bound (at K = 4 and Asymptotic: n = 1000)		
Significant level	Lower (1(0)	Upper 1(1)	
10%	2.20	3.09	
5%	2.56	3.49	
2.5%	2.88	3.87	
1%	3.29	4.37	
Critical Values at Bound (at K = 4 and Finite sample: n = 35			
10%	2.460	3.460	
5%	2.947	4.088	
1%	4.093	5.532	

Actual sample size (n) =27. Null hypothesis: No level relationship.
Source: Extracted from analysis by author.

The estimated long run coefficients of ARDL model

The long-run results showed that the total credit granted to the agricultural sector (CAGRt) by commercial banks has a positive significant association with livestock production with a probability of 1%. This result implies that an increase in total agricultural sector credit per unit will result in a 0.364% increase in livestock production index in Nigeria. The finding also shows the inelastic relationship between total credit to the agricultural sector and livestock production in Nigeria. This means that the change in total livestock production is less than the change in total credit allocated to the agricultural sector by commercial banks in the country. The finding is similar to empirical reports by Khan et al. (2007), Abedullah et al. (2009), Khan et al. (2018), Olagunju and Babatunde (2011), Rahman et al. (2011), Kuye (2013) and Shiferaw et al. (2015).

The results also showed that the guaranteed loan to livestock farms/farmers from the Agricultural Credit Guarantee Scheme Fund (ACGt) has a negative significant correlation with livestock production in the long run with a probability of 1%. This suggests that an increase in the guaranteed loan for the livestock subsector will reduce the productivity index of the subsector by 0.222%. The finding contradicts the a priori expectation. Several factors could be responsible for the occurrence of this result. First, the question of timely provision of the credit facility is a serious issue that needs to be addressed. Since agricultural activities are largely regulated by natural phenomena such as rainfall, seasons, etc., timely disbursement of loans is of utmost importance for increasing livestock production. Second, widespread corruption among loan managers also contributed to this result. However, if, for example, loans are diverted to unintended beneficiaries, the amount of loans disbursed is allocated to the livestock subsector. The third factor is attributed to the poor monitoring and evaluation of the credit process and the high default rate, which prevented efficient reuse of the credit process. The finding confirms the reports of Zakaree (2014), but contradicts the empirical submissions of Orok and Ayim (2017), Khan et al. (2007), Abedullah et al. (2009), Khan et al. (2018), Olagunju and Babatunde (2011), Rahman et al. (2011), Kuye (2013), Shiferaw et al. (2015), Abu (2017) and Reuben et al. (2020).

Table 5. The long-run coefficients for livestock gross production index equation.

Variable	Coefficient	Standard error	t-value		Probability
Constant	2.944236	0.615501	4.783482	***	0.0004
$CAGR_t$	0.364708	0.120002	3.039175	***	0.0095
ACG_t	-0.221529	0.073657	-3.007576	***	0.0101
LEN_t	0.143117	0.172987	0.827327		0.4230
$DCPS_t$	0.145806	0.032323	4.510906	***	0.0006

Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are expressed in natural logarithms. ARDL (1, 1, 2, 1, 4) selected based on Schwarz Bayesian Criterion.
Source: computed by the authors.

The coefficient of domestic credit to the private sector has a significant positive relationship with the gross livestock production index in Nigeria. The findings revealed that a 0.146% increase in domestic credit to the private sector would lead to an increase in the livestock production index. Alternatively, increasing domestic credit to the private sector would increase livestock production in Nigeria. The result meets the a priori expectation as the increase in domestic credit to the private sector increases investment in the real sectors of the economy. The country has recently made massive investments in agro-industrial units, particularly poultry feed, agrochemicals, and hatchery production, mainly driven by the private sector. Since the agriculture sector is one of the preferred sectors for private sector investment, it has enjoyed the support of investors, which has resulted in a corresponding increase in the sector's production. The finding is consistent with the reports of Khan et al.

(2007), Abedullah et al. (2009), Khan et al. (2018), Olagunju and Babatunde (2011), Rahman et al. (2011), Kuye (2013) and Shiferaw et al. (2015).

The estimated short run coefficients of ARDL model

The result in Table 6 shows estimates of the error correction representation of the ARDL model. The ECM coefficient is negative and statistically significant at 1% probability level. This confirms the existence of cointegration between the specified variables. The coefficient of the ECM represents the speed of adjustment in the long-run equilibrium after short-run shocks. This shows that annually about 45.19% of the short-run disequilibrium is adjusted towards its long-run equilibrium. Alternatively, about 45.19% of the disequilibrium from the previous year's shock converge back to the long-run equilibrium in the current year. The diagnostic tests for the ECM model revealed an R2 value of 0.7828, which indicates that the agricultural credit policy variables explained about 78.29% of the adjusted total variations in livestock production in the country.

The empirical result showed that the total credit provided to the agricultural sector by the commercial banks at the current level has a positive and significant short-run impact on livestock production in Nigeria. For instance, a 100% increase in the commercial bank total credit to the agricultural sector will positively change the gross livestock production index by 5.19% in the short run. This means that an increase in the current commercial bank total credit to the agricultural sector would boost livestock production. A similar result was obtained for the long-run relationship. This finding is consistent with the empirical claim of Abedullah et al. (2009), Khan et al. (2018), Olagunju and Babatunde (2011), Rahman et al. (2011), Kuye (2013), Shiferaw et al. (2015), Abu (2017), Reuben et al. (2020), Umboh et al. (2021), and Adewale et al. (2022).

The Livestock Subsector Guarantee Loan through ACGS showed a significant negative association with livestock production in the short run. This means that if the value of the loan guarantee for livestock beneficiaries increases by one unit, the livestock production index will decrease by 0.052% in the short run. This result is similar to the long-run relationship and is supported by Zakaree (2014). However, the previous year's value of the guaranteed loan for the livestock subsector correlates positively with the current year's livestock production index. The finding leads to the fact that the slope coefficient of the previous year's loan guarantee in the livestock subsector has a stimulating influence on the current year's gross livestock production in Nigeria. The result is consistent with the reports of Orak and Ayim (2017), Khan et at. (2007), Abedullah et al. (2009), Khan et al. (2018), Olagunju and Babatunde (2011), Rahman et al. (2011), Kuye (2013), Shiferaw et al. (2015), Abu (2017), and Reuben et al. (2020). The coefficient of the lending interest rate has a significant negative relationship with the livestock production index in the short run. For example, a 10% increase in the lending rate results in a 1.03% decrease in the gross livestock production index. This means that as lending interest rates rise, livestock production will decline in the short run. The result is consistent with the a priori finding, as an increase in the lending rate is known to increase agricultural risk and limit farmers' capacity to expand production and agricultural investment. The finding is consistent with the reports of Udoka et al. (2016), Asekome and Ikojie, (2018), and Iliyasu, (2019); however, it contradicts the submission of Salisu and Alamu (2023).

Table 6. The short-run coefficients for livestock gross production index equation (restricted constant).

Variable	Coefficient	Standard error	t-value	Probability
D(CACG)	0.051871	0.025990	1.995818 *	0.0673
D(ACG)	-0.080722	0.018495	-4.364484 ***	0.0008
D(ACG(-1))	0.056655	0.017037	3.325331 ***	0.0055
D(LEN)	-0.102767	0.054502	-1.885555 *	0.0819
D(DCPS)	0.034730	0.042041	0.826089	0.4237
D(DCPS(-1))	-0.060044	0.029710	-2.020994 *	0.0644
D(DCPS(-2))	-0.042697	0.025257	-1.690489	0.1148
D(DCPS(-3))	-0.121366	0.030932	-3.923610 ***	0.0017
ECM (-1)	-0.451944	0.061706	-7.324124 ***	0.0000
		Diagnostic Test		
R-Squared	0.782829	Adjusted R-Squared		0.6863309

Note: ***, and ** indicate 1% and 5% significance level respectively. Variables are expressed in natural logarithm difference. ARDL (1, 1, 2. 1, 4) selected based on Schwarz Bayesian Criterion.
Source: computed by the authors.

Furthermore, the coefficients of domestic credit to the private sector in the previous year and the previous three-year period show a negative significant association with livestock production in Nigeria. The results showed that there will be a decrease in the livestock production index by 0.060% and 0.121% with an increase in domestic credit to the private sector in the previous one- and three-year periods, respectively. The risky nature of agribusiness, the low returns of the agricultural sector and the reluctance of the private sector and banks to invest in the agricultural sector in the short run could help explain the results. For example, the risky nature of agricultural production in the country has prevented several private investors and financial institutions from investing in agriculture in the short run. The finding is supported by the empirical results of Zakaree (2014).

Diagnostic test of the short run model

The Breusch-Godfry serial correlation (LM test) of 1.917466 shows that the serial correlation is insignificant. The ECM model has proven to be robust to residual autocorrelation. Therefore, even the presence of serial autocorrelation does not affect the estimates (Laurenceson, 2003). In addition, the null hypothesis was not rejected for the RESET test, the Breusch-Pagan test, the normality test and the CUSUM test. This means that the estimated ECM model has structural rigidity, no heteroscedasticity, a normally distributed error term, and is stable within the specified time frame.

Table 7. Diagnostic statistics

Test	Value	Probability
Ramsey RESET Test	0.510192	0.6192
Normality test (Jarque-Bera)	0.525004	0.7691
Heteroscedasticity (Breusch-Pagan-Godfrey)	1.226676	0.3590
Breusch-Godfrey Serial Correlation LM Test	1.917466	0.1930

Note: prepared by authors.
Source: Authors' calculations.

Test of the Stability of the ARDL ECM

The cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) plots derived from the recursive estimation of the ARDL-ECM model are shown in Figures 1 and 2, respectively. The results indicate stability of the ARDL-ECM coefficients over the sample period, as the representation of the CUSUM and CUSUMSQ statistics lies within the critical bands of the 5% confidence interval (or 95% probability levels) of parameter stability.

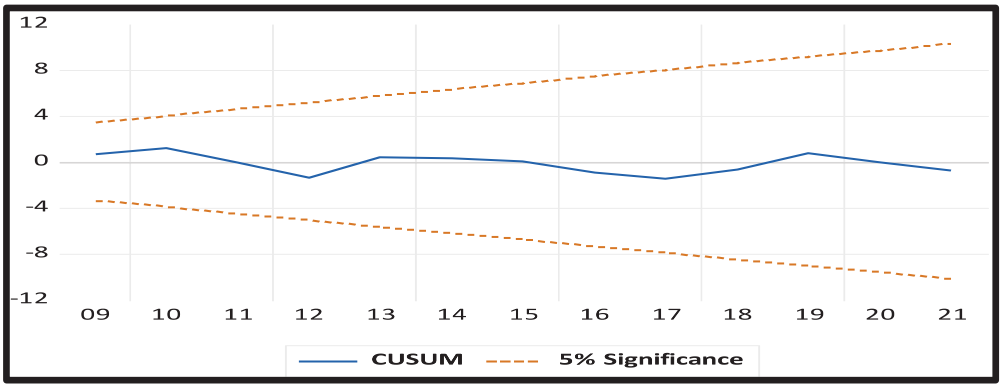


Fig. 1. Plot of CUSUM for coefficients' stability of ARDL model

Source: Generated from data analysis by authors.

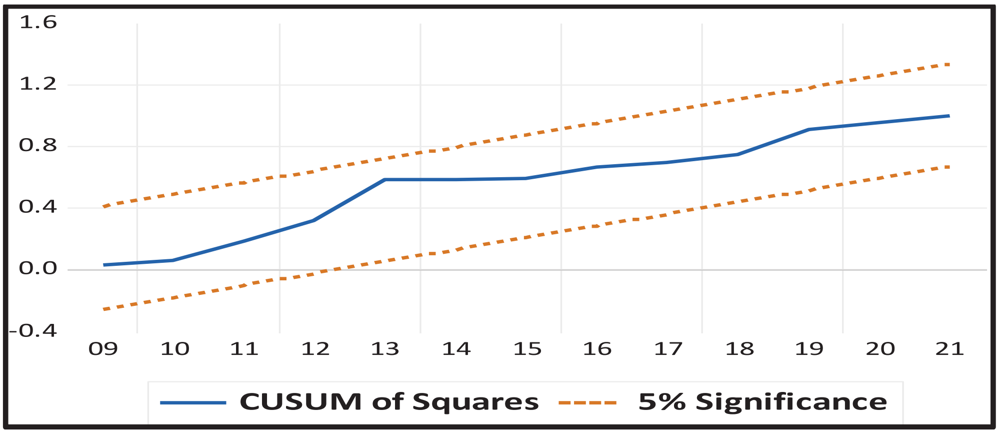


Fig. 2. Plot of CUSUMSQ for coefficients' stability of ARDL model

Source: Generated from data analysis by authors.

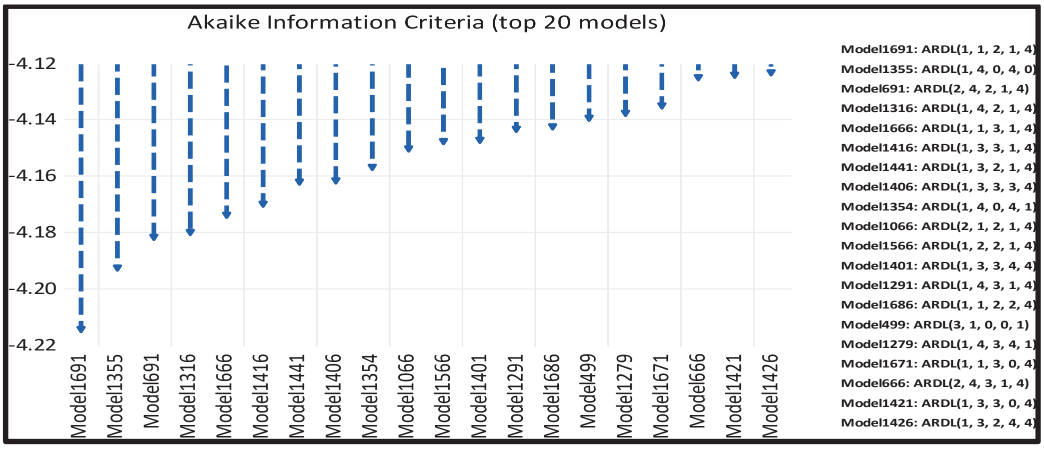


Fig. 3. Akaike information criteria graph.

Source: Generated from data analysis by authors.

Conclusion

The main objective of this research was to establish an empirical relationship between some agricultural credit policy variables and the growth of the livestock sub-sector in Nigeria. Time series data were sourced from the World Bank (WB), Food and Agriculture Organization (FAO) and Central Bank of Nigeria (CBN).

ADF and ADF-GLS were used to check the stationarity or unit root of series. The estimated results of ADF and ADF-GLS showed that the lending interest rate was stationary at level I(0), while other variables were stationary at the first difference 1(1). The autoregressive distributed lag (ARDL)-bound co-integration test was used to analyze the data. After confirming cointegration of the specified variables, the long- and short-run models of the livestock gross production index equations were estimated with the error term having the appropriate sign and being statistically significant at the conventional probability level. The results showed that the commercial bank total credit to the agricultural sector had a positive and significant impact on livestock production in both the long and short runs. On the other hand, the agricultural credit guarantee scheme loan allocated to the livestock subsector had a negative correlation with livestock production index in both the short and long run. The lending interest rate had a negative short-run relationship with the livestock production index. The total domestic credit to the private sector showed a positive relationship with gross livestock production index in the long run and a negative relationship in the short run. The results suggest that credit policy variables have a significant impact on the output of the livestock subsector in Nigeria.

Based on these empirical facts and the need to boost livestock production in Nigeria, it is recommended that the overall credit to the agricultural sector from the commercial banks be increased to provide an incentive to increase livestock production. Additionally, domestic lending to the private sector should be strengthened or increased to boost livestock production. In addition, the current lending interest rate in the country should be reduced to improve access to credit for livestock farms. The Agricultural Credit Guarantee Scheme loan for the livestock sub-sector should be reassessed and monitored to achieve the desired objective.

References

Abedullah, N. Mahmood, M. K., Kouser, S. (2009). The role of agricultural credit in the growth of livestock sector: a case study of Faisalabad. *Pakistan Veterinary Journal,* 29(2), 81-84.

Abu, O. (2017). Impact of agricultural credit guarantee scheme fund (ACGSF) on livestock production in Nigeria: evidence from historical data. *Journal of Agriculture and Environment,* 13(2), 1-11.

Adebayo, O.O., Adeola, R.G. (2008) Sources and Uses of Agricultural Credit by Small-Scale Farmers in Surulere Local Government Area of Oyo State. Anthropologist, 10, 313-314.

Adewale, A.T., Lawal, O.A., Aberu, F., Toriola, A.K. (2022). Effect of credit to farmers and agricultural productivity in Nigeria. *East Asian Journal of Multidisciplinary Research*, 1(3), 377-388.

Akpan, S.B. (2022). Trends in major ruminant meats production and the roles of the macroeconomic environment in Nigeria. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Developmen*t, 22(4), 49-62.

Akpan, S.B., Uwemedimo E.O., Ima-abasi S.A. (2019). Poverty coping strategies of oil palm farmers in Akwa Ibom State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 15(1),20-30.

Akpan, S.B., Edet J.U., Inimfon V.P. (2016). Sustaining Small Scale Farming: Evidence of Poverty and income Disparity among Rural Farming Households in South-South Region of Nigeria. Path of Science. *International Electronic Scientific Journal*, 2,9(14), 4.9-4.23.

Akpan, S.B., Nkanta, V.S. (2022). Trend Analysis and Macroeconomic Variable Determinants of Egg Production in Nigeria. *Journal of Agricultural Production*, 3(2), 100-109.

Akpan, S.B., Udo, U.J. (2021). Indigenous meat and milk gross production indexes and the dynamic macroeconomic fundamentals in Nigeria: ARDL model approach. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 21(3), 97-110.

Akpan, S.B., Inimfon V.P., Samuel J.U., Edem A.O., Uwemedimo E.O. (2013). Determinants of Credit Access and Demand among Poultry Farmers in Akwa Ibom State, Nigeria. *American Journal of Experimental Agriculture*, 3(2), 293-307.

Akpan, S.B., Akpan, O.D., Essien, U.A. (2012). Government Agricultural Credit Policy and Macroeconomic Fundamentals: a case study of Agricultural Credit Scheme Fund (ACGSF) in Nigeria. *Public Policy and Administration Research*, 2(2), 61-75.

Akpan, S.B., Offor, O.S., Archibong, A.E. (2020). Access and demand for credit among small scale agro-based processors in Uyo agricultural zone, Akwa Ibom State, Nigeria. *Nigerian Journal of Agriculture*, 51(1), 132-141.

Asekome M., Ikoje, S. (2018). An Empirical Investigation on Impact of Interest Rates on Agricultural Investment in Nigeria. *Journal of Economics and Business*, 1(1), 71-82. DOI: 10.31014/aior.1992.01.01.7.

Asom, S.T., Ewuruje, A., Ijirshar, V.U., Ogoda, S.I. (2023). Impact of informal credit on output of small scale farmers in Nigeria. *Journal of Public Administration, Finance and Law*, 27, 38-57. doi.org/10.47743/jopafl-2023-27-03.

Assogba, P.N., Kokoye, S.E., Yegbemey, R.N., Djenontin, J.A., Tassou, Z., Pardoe, J., Yabi, J.A. (2017). Determinants of credit access by smallholder farmers in North-East Benin. *Journal of Development and Agricultural Economics*, 9(8), 210-216. DOI: 10.5897/JDAE2017.0814.

Awotide, B.A., Abdoulaye, T., Alene, A., Manyong, V.M. (2015). Impact of Access to Credit on Agricultural Productivity: Evidence from Smallholder Cassava Farmers in Nigeria. A Contributed paper Prepared for Oral Presentation at the International Conference of Agricultural Economists (ICAE) Milan, Italy August 9-14.

Beck, T., Demirguc-Kunt, A. (2006). Small and medium-size enterprises: Access to finance as a growth constraint. *Journal of Banking & Finance*, 30(11), 2931-2943.

Carrer, A.J., Maia, A.G., Vinholis, M.B., Filho, H.M. (2020). Assessing the effectiveness of rural credit policy on the adoption of integrated crop-livestock systems in Brazil. *Land Use Policy*, 92, 104468, https://doi.org/10.1016/j.landusepol.2020.104468.

CBN (2022). Monetary, Credit, Foreign Trade and Exchange Guidelines for Fiscal Year 2022/2023. Accessed online on the 25th of September, 2023, at: https://www.cbn.gov.ng/Out/2022/MPD/Credit%20Guidelines%202022%20-2023%2020.05.2022.pdf.

Chisasa, J., Makina, D. (2013). Bank Credit and Agricultural Output in South Africa: A Cobb-Douglas Empirical Analysis. *International Business & Economics Research Journal*, 12(4), 387-398.
Dickey, D.A., Fuller, W.A. (1979). Distribution of the estimators for autorregressive time series with a unit root. *Journal of the American Statistical Association*, 74, 427-31.
Duguma, A.L., Debsu, J.K. (2019). Determinants of Livestock Production Development of Smallholder Farmers'. *Journal of Applied Sciences and Environmental Management*, 23(8), 1535-1540.
Elliot, G., Rothenberg, T.J., Stock, J.H. (1996). Efficient tests for an autoregressive unit root. *Econometrica*, 64, 813-836.
Engle, R.F., Granger, C.W.J. (1987). Co-integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, 55, 251-276.
Essien U.A., Arene C.J. (2014). An analysis of access to credit markets and the performance of small scale agro-based enterprises in the Niger Delta region of Nigeria. *International Journal of Food and Agricultural Economics*, 2(3), 105-120. https://doi.org/10.22004/ag.econ.186271.
Essien, U.A., Ibekwe, U.C., Akpan, S.B., Ben-Chendo N.G. (2016). Determinants of Informal credit Delinquency among Food Crop Farmers in rural Niger delta of Nigeria. R*eview of Agricultural and Applied Economics*, 19(1), 50-55.
Federal Ministry of Agriculture and Food Security, (2023). Available at: https://fmard.gov.ng/.
Food and Agricultural Organization document (2023). Available at: https://www.fao.org/nigeria/fao-in-nigeria/nigeria-at-a-glance/en/.
Harris, R., Sollis, R. (2003). Applied Time Series Modeling and Forecasting. Wiley, West Sussex.
Hatab, A.A, Cavinato, M.E.R., Lagerkvist, C.J. (2019) Urbanisation, livestock systems and food security in developing countries: A systematic review of literature. *Food Security,* 11, 279-299. https://doi.org/10.1007/s12571-019-00906-1.
Hennessy, D., Shalloo, L., Van Zanten, H., Schop, M., De Boer, I. (2021). The net contribution of livestock to the supply of human edible protein: The case of Ireland. *The Journal of Agricultural Science*, 159(5-6), 463-471. doi:10.1017/S0021859621000642.
Herrero, M., Grace, D., Njuki, J., Johnson, N., Enahoro, D., Silvestri, S., Rufino, M.C. (2013). The roles of livestock in developing countries. *Animal*, 7:s1, 3-18. doi:10.1017/S1751731112001954.
Idiong, I.C., Ubon, A.E., Sunday, B.A. (2010). Determinants of frequency of Disbursement of Credit to Food Crop Farmers by informal lending groups in Akwa Ibom State of Nigeria: A Poisson regression approach. *Nigerian Southeast Journal of Agricultural Economics and Extension,* 9(1&2), 23-27.
Iliyasu, A.S. (2019). An Empirical Analysis of the Impact of Interest Rate on Agriculture in Nigeria. *Journal of Economics and Sustainable Development*, 10(22), 106-112.
Jeiyol, E.N., Sunday, B.A., Terver, N.T. (2013). Gender Analysis of Access to Credit by Rural Small Scale Farmers in Benue State Nigeria. *American International Journal of Social Science*, 2(6), 70-78.
Johansen, S., Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210.
Khan, K., Kamal, M.A., Ramazan, S., Khan, G., Ali, G., Ahmed, S. (2018). Impact of agricultural credit on livestock income: a case study of district Lasbela, Balochistan. *Sarhad Journal of Agriculture*, 34(2), 246-250.
Khan, N., Jan, I., Rehman, M. U., Latif, M. U., Akhtar A. (2007). The impact of micro credit on livestock enterprise development in district Abbottabad (a case of SRSP micro credit programme). *Sarhad Journal of Agriculture*, 23(4), 1205-1210.
Kuye, O.O. (2013). Effects of Micro-Credit on Livestock Production among Smallholder Livestock Farmers in Yakurr LGA, Cross River State, Nigeria. *International Journal of Science and Research*, 5(9), 65-68. DOI: 10.21275/20081603.
Laurenceson, J., Chai, J.C.H. (2003). Financial reforms and economic development in China. Cheltenham, UK, Edward Elgar., 1-28.
Manyong, V.M., Ikpi, A., Olayemi, J.K., Yusuf, S.A., Omonona, B.T., Okaruwa V., Idachaba, F.S. (2005). Agriculture in Nigeria: Identifying Opportunities for Increased Commercialization and Investment. IITA, Ibadan, Nigeria, pp: 159.
Olagunju, F.I., Babatunde, R.O. (2011). Impact of Credit on Poultry Productivity in South-Western, Nigeria. *ARPN Journal of Agricultural and Biological Science*, 6(10), 58-65.
Ololade, R.A., Olagunju, F.I. (2013). Determinants of access to credit among rural farmers in Oyo State, Nigeria. *Global Journal of Science Frontier Research Agriculture and Veterinary Sciences*, 13(2), 17-22.
Olomola, A.S., Yaro, M. (2015). Commercial Banks' Response to Government's Financial Stimulus for Improved Agricultural Financing in Nigeria. NSSP Working Paper 28. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/129209.

Omolade, O.K., Adepoju, A.O. (2019). Credit Constraints and Agricultural Productivity of Rural Households in Nigeria. *Journal for the Advancement of Developing Economies*, 8(1), 1-15.
Oyelade, A.O. (2019). Impact of commercial bank credit on agricultural output in Nigeria. *Review of Innovation and Competitiveness*, 5(1), 5-20.
Orok, A.B., Ayim, S.A. (2017). The Impact of Agricultural Credit Guarantee Scheme Fund on Agricultural Sector Development in Nigeria. *International Review of Management and Business Research,* 6(3), 1104-1116.
Pesaran, M.H., Shin, Y. (1999). An autoregressive distributed lag modelling approach to cointegration analysis. In Storm, S. (eds), Econometrics and Economic Theory in 20th Century: The Ragnar Frisch Centennial Symposium. Cambridge: Cambridge University Press.
Pesaran, M.H., Shin, Y., Smith, R.J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, 289-326.
Pexas, G., Doherty, B., Kyriazakis, I. (2023). The future of protein sources in livestock feeds: implications for sustainability and food safety. *Frontier Sustainable Food System*, 7, 1188467. doi: 10.3389/fsufs.2023.1188467.
Rahman, W.M., Jianchao, L., Enjiang, C. (2011): Policies and performances of agricultural/rural credit in Bangladesh: What is the influence on agricultural production? *African Journal of Agricultural Research,* 6(31), 6440-6452.
Reuben, J., Nyam, C.M., Rukwe, D.T. (2020). Agricultural credit guarantee scheme fund and its effect on agricultural output in Nigeria. *Review of Agricultural and Applied Economics*. 23(2), 102-111. doi:10.15414/raae.2020.23.02.102-111.
Salisu, T.Q., Alamu, O.K. (2023). Effect of Bank Lending on Agricultural Output in Nigeria From 1981–2021 (Auto-regressive Distribution Approach). doi: https://doi.org/10.21203/rs.3.rs-3235799/v1.
Shiferaw, K., Geberemedhin, M., Legesse, D. (2015). What factors affect households' decision to allocate credit for livestock production? Evidence from Ethiopia. Available online at https://mpra.ub.uni-muenchen.de/69344/MPRA Paper No. 69344, posted 10 Feb 2016 06:12 UTC.
The Federal Ministry of Environment 2021. https://environment.gov.ng/. retrieved on the 21st of May, 2021.
Thornton, P.K., Kruska, R.L., Henninger, N., Kristjanson, P.M., Reid, R.S., Atieno, F., Odero, A.N., Ndegwa, T. (2002). Mapping Poverty and Livestock in the Developing World. Nairobi: International Livestock Research Institute.
Udoka, C.O., Mbat, D.O., Duke, S.B. (2016). The effect of commercial banks' credit on agricultural production in Nigeria. *Journal of Finance and Accounting*, 4(1), 1-10.
Umboh, S.J.K., Kalangi, J.K.J., deRosari, B. (2021). The effect of agricultural credit policy and cattle-raising business input productivity on farmer household welfare. IOP Conference Series: Earth and Environmental Science. 637 012093. doi:10.1088/1755-1315/637/1/012093.
Umoren, A.A., Eyo, E.O., Akpan, S.B. (2018). Investigating the nexus between Non-Performing Loans in the Nigerian Banking System and Lending to Micro-Small Medium Enterprises. *International Journal of Contemporary Research and Review*, 9(6), 20778-20791.
Umoren, A.A., Udoh, E.J., Akpan, S.B. (2016). Analysis of loan default among agricultural credit guarantee Scheme (ACGS) loan beneficiaries in Akwa Ibom State, Nigeria. *African Journal of Agricultural Economics and Rural Development*, 2(2), 121-128.
Varijakshapanicker, P., Mckune, S., Miller, L., Hendrickx, S., Balehegn, M., Dahl, G.E., Adesogan, A.T. (2019). Sustainable livestock systems to improve human health, nutrition, and economic status. *Animal Frontiers*, 9(4), 39-50. doi: 10.1093/af/vfz041.
Zakaree, S.S. (2014). Impact of Agricultural Credit Guarantee Scheme Fund (ACGSF) on Domestic Food Supply in Nigeria. *British Journal of Economics, Management & Trade*, 4(8), 1273-1284.

For citation:

Akpan S.B., Udoh E.J., Nkanta V.S. (2023). Agricultural Credit Policy and Livestock Development in Nigeria. *Problems of World Agriculture*, 23(3), 45-60; DOI: 10.22630/PRS.2023.23.3.11

Scientific Journal Warsaw University of Life Sciences – SGGW
Problems of World Agriculture volume 23(XXXVIII), number 3, 2023: 61-73
DOI: 10.22630/PRS.2023.23.3.12

Emeka Osuji[1✉], Christiana Igberi[2], Emmanuel Osang[3], Akunna Tim-Ashama[4], Esther Nwachukwu[5]
[1,2,3] Alex Ekwueme Federal University, Ndufu-Alike, Ebonyi State, Nigeria
[4] Alvan Ikoku Federal College of Education, Owerri, Imo State, Nigeria
[5] Federal University of Technology, Owerri, Imo State, Nigeria

Climate Change and Sweet Potato Production; Empirical Insights from Ebonyi State, Nigeria

Abstract. Climate change poses significant challenges to agriculture and land productivity particularly in regions heavily dependent on rain-fed agriculture like Ebonyi State, Nigeria. This study analyzed the effects of climate change on sweet potato production in Nigeria. Multi-stage sampling procedure was used to select 301 respondents. The drafted questionnaire was used for data collection following the specific objectives of study. Descriptive statistics, land productivity model, and multiple regression model were used for the data analysis. Results revealed that the majority of respondents (64.1%) were males, married (73.1%), young (42.2%), experienced (55.5%) and relatively educated (49.8%) with household and farm sizes of 7 and 1.8 hectares. The majority of the farmers (41.5%) were aware of changes in climate. Farm sizes of 1.1-2.0 hectares produced the highest land productivity (1769.831 hectares) in the state from about 51.5% of the farmers. Rising temperature, rainfall, and number of rainy days, influenced sweet potato production negatively; while sunshine hours and relative humidity had significant positive influences. Poor access to extension and services, land fragmentation, capital, inadequate information concerning climate change, and high cost of input resources constrained potato cultivation. The study recommends farmers to practice climate smart agricultural techniques and to seek early climate change information to mitigate negative effects of changing climate on sweet potato production.

Keywords: temperature, rainfall, sunshine, relative humidity, multi-stage, land productivity

JEL Classification: Q12, Q18

Introduction

Despite being historically farmed, sweet potato is gradually becoming an important commercial crop among Africa's rural poor. The crop is currently and widely farmed as a significant staple food in several African nations, including Gambia, Ghana, and Nigeria, where it is grown by peasant and small-holder farmers (Abdurahman et al., 2017). Globally, about 133 million tons is produced annually, making sweet potato (*Ipomoea batatas [L.] Lam*) one of the world's most significant, adaptable, and underutilized food crops (Akande et

[1] Department of Agriculture, Alex Ekwueme Federal University Ndufu Alike Ebonyi State, Nigeria, e-mail: osujiemeka2@yahoo.com; https://orcid.org/0000-0001-8605-834X; Corresponding author
[2] Department of Agriculture, Alex Ekwueme Federal University Ndufu Alike Ebonyi State, Nigeria; https://orcid.org/0000-0002-6841-8812
[3] Department of Agriculture, Alex Ekwueme Federal University Ndufu Alike Ebonyi State, Nigeria
[4] Department of Agricultural Science, Alvan Ikoku Federal College of Education Owerri Imo State, Nigeria; https://orcid.org/0000-0002-0556-9437
[5] Department of Agricultural Economics, Federal University of Technology Owerri Imo State, Nigeria; https://orcid.org/0000-0002-3728-1550

al., 2017). In developing nations including Nigeria, the crop is regarded as the most unseen cultivated food crop after rice, wheat, maize, and cassava (Alemu &Addisu, 2021). It is the only root and tuber crop in Sub-Saharan Africa with a 125% per capita annual rate of increase in output (FAO, 2022). Sweet potato is particularly beneficial in developing nations since it is a food security crop for the poor holder farmers who often cultivate it for subsistence gains. It supplies an essential source of nutritional carbs for human and animal consumption. It is also high in carotenoids and pro-vitamin A.

Furthermore, sweet potato is an important resource in underdeveloped nations due to its high levels of nutrition, productivity, and low levels of input utilization (Bassey et al., 2019). China is reported as the world's largest producer of sweet potato (75.80 million tons per year) (FAO, 2022). Currently, Nigeria is now Africa's leading producer of sweet potato, with an annual production of 3.46 million metric tons, and the world's second largest producer after China (Chikezie et al., 2019). Sweet potato, unlike cereal crops (rice, wheat, and maize), is not a globally traded commodity, and its prices are mainly decided by domestic supply and demand, making it an intriguing case study in Nigeria. Crop productivity is projected to suffer as greenhouse gases build in the atmosphere, causing global warming and concomitant changes in hydrological regimes (Arora, 2019).

Climate change has, in fact, been extensively observed to have an impact on crop productivity in Africa and Nigeria, particularly sweet potato cultivation (Asrat &Simane, 2018). Despite advances in agricultural technology such as the use of inorganic fertilizers, modern land preparation, planting of early season crops, farm mechanization, the use of agrochemicals, improved seed varieties, irrigation system expansion, and genetically modified crops, among others, weather and climate continue to be major challenges to agricultural production (Diriba et al., 2019). Climate change, according to the Intergovernmental Panel on Climate Change (IPCC), is a change in the state of the climate that can be defined by changes in the mean and/or weather variability that lasts for a protracted period of time, generally decades. Changes in global warming could also be caused by human-induced variables (Ebele &Emodi, 2016). Globally, it is regarded as the most important environmental issue confronting the world, wreaking havoc on agriculture and changing life patterns and general living circumstances (FAO, 2022). It has ramifications like disrupting seasonal cycles, hurting ecosystems and water supplies, impacting agricultural farming systems and food production, raising sea levels, and so on (Elia, 2017). However, agriculture's survival is dependent on climate, and the two are intertwined since they both occur globally. In Nigeria, climate change is having a severe influence on agricultural activity (Haider, 2019). Sweet potato production in the country has come under serious threat; as a result, both yearly and domestic output have decreased, impoverishing farmers and limiting their financial returns (Esan &Omilani, 2018).

Climate change has limited sweet potato growers' ability to increase their acreage cultivation, resulting in low and poor output. Potato farmers' vulnerability to growing poverty is exacerbated by low output yield, and thus deteriorating their living conditions. Land degradation caused by climate change hinders sweet potato production, productivity, yield, output, and revenue of farmers in general (Gray, 2021). Land degradation results in land fragmentation and does not support or encourage soil management measures and farm mechanization required for sweet potato development (Feleke et al., 2019). Again, in Nigeria, around 90% of sweet potato farmers are small-scale farmers who cultivate fragments of land and rely exclusively on rainfall rather than irrigation systems, making climate change a significant contributor to sweet potato output in Nigeria (Ifeanyi-Obi &Asiabaka, 2014). The variability and irregularities of rainfall patterns and distribution limit sweet potato output and skew economic returns of sweet potato farmers who rely on it for survival and economic livelihoods (Lemessa et al., 2019). Higher temperatures distort seed germination and cause tremendous harm to potato plant growth and leaf development. Higher temperatures also affect the storability of harvested potato tubers.

Similarly, sweet potato farmers in Ebonyi State have equally had their share of adverse climate change effects and this portrays the true purpose of the study. Climate change has influenced sweet potato production and yield in the state, thereby creating artificial food scarcity and food insecurity in the state. Based on economic theories on food demand and supply gap, which posit a greater demand on food commodities against low supplies, calls for immediate actions and policies to sustain food production and security in the state are increasingly relevant. However, this study differs from previous studies on cereal crops such as rice, wheat, maize, sorghum, and tuber crops such as cassava, yam, cocoyam, (Boansi, 2017; Wang et al. 2018; Asfew &Bedemo, 2022; Rettie et al., 2022; Mariem et al., 2021) because it focuses on sweet potatoes. Sweet potatoes are one of Nigeria's under-exploited and forgotten food crops which contributes significantly to Nigeria's gross domestic product, as the country is the major producer in Africa and second largest producer in the world. The study contributes to the knowledge and body of literature by empirically highlighting the effects of climate change on sweet potato production. Further, this study is the first study in sub-Saharan Africa and Nigeria to use climate variables (temperature, rainfall, sunshine, and relative humidity) to express how climate change influences sweet potato production.

The objective of the study is to assess how climate change affects sweet potato production in Ebonyi State, Nigeria.

Materials and methods

The research was carried out in Ebonyi State, Nigeria. The state is a significant grower of sweet potatoes in Nigeria. It consists of twelve Local Government Areas. According to the National Bureau of Statistics, the area's population in 2006 is estimated to be 3,490,383. The respondents were chosen using a multi-stage sampling approach. In the first stage, four local government areas (LGAs) were chosen from each of the state's three agricultural zones; Ebonyi North, Ebonyi South, and Ebonyi Central, for a total of 12 LGAs. In the second step, four independent communities were chosen at random to form 48 communities. Three villages were chosen in the third stage to make 144 villages. The final and last stage involved a random selection of 5 sweet potato growers, for a total of 720 responses. The study relied on primary data collected via a structured questionnaire. The questionnaire was developed in accordance with the study's specific goals and was pretested before being administered to the sampled respondents. The study questionnaire covered the 2022/2023 farming season. The purpose for the questionnaire pre-testing was to assess its substance and reliability for the research. According to the distribution of questionnaires among respondents, only 301 questionnaires were considered useful for data analysis. Data were analyzed using descriptive statistics, land productivity model and multiple regression technique. The land productivity model is specified as:

$$L_p = \frac{To}{Ti} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:
Lp = Land productivity measured in Naira.
To= Total output measured in Naira
Ti = Total input used in production measured in Naira.

The multiple regression model is stated as follows:

$$Y = F(b1 * X1 + b2 * X2 + b3 * X3 + b4 * x4 + b5 * x5) + e \ldots\ldots\ldots\ldots\ldots (2)$$

where:
Y= Land productivity of the potato farmers (Naira).
bi= Parameter estimates.
X1= Temperature (Measured as dummy; Increased =1, Otherwise = 0).
X2= Rainfall (Measured as dummy; Increased =1, Otherwise = 0).
X3= Number of rainy days (Measured as dummy; Increased =1, Otherwise = 0).
X4= Relative humidity (Measured as dummy; Increased =1, Otherwise = 0).
X5= Sunshine (Measured as dummy; Increased =1, Otherwise = 0).
e = Error term.

Results and discussion

The socio-economic characteristics of sweet potato farmers are shown in Table 1. According to the data, 42.2% of the farmers were between the ages of 41 and 50, with a mean age of 48. This suggests that the farmers were middle-aged people and physically fit enough to carry out their sweet potato growing (Fierros-Gonzalez &Lopez-Feldman, 2021). Males made up 64.1% of sweet potato farmers, while females made up 35.9%. This means that males dominate sweet potato production due to their access to lands, farm inputs, financing facilities, and so on, as opposed to female farmers who had restricted access to agricultural inputs. Furthermore, agricultural production entails certain work that only male farmers can do due to their physical strength (Feleke et al., 2019).

The majority of farmers were married (73.1%), meaning that married farmers have additional family labor as a result of their marriage (children) and, in most cases, dependents living with them. This also demonstrates that married farmers are more focused, dedicated, and committed to their agricultural operation than single farmers (Fischer et al., 2017). According to the table, 32.9% of farmers had elementary education, 13.6% had higher education, and 3.7% had no formal education. Thus, 49.8% of the farmers had a secondary education, implying that the farmers can read and write, as well as analyze and grasp farm production techniques and activities aimed toward enhanced potato output (Alemu &Addisu, 2021). The majority of farmers (59.5%) had family sizes ranging from 5-8 people, with a mean household size of 7. This suggests that the sweet potato farmers' household size was rather substantial and providing support to their production operations. A large home offers more family labor than a small household (Keba, 2019).

Table 1. Socio-economic characteristics of sweet potato farmers

Variable	Frequency	Percentage	Variable	Frequency	Percentage
Age			**Cooperative membership**		
20-30	77	25.6	Yes	121	40.2
31-40	89	29.6	No	180	59.8
41-50	127	42.2	**Participation in workshop/training**		
51& above	08	2.7	1-2	108	35.9
Mean	**48**		3-4	182	60.5
Sex			5-6	06	1.9
Male	193	64.1	7 & above	05	1.7
Female	108	35.9	**Mean**	**3.3**	
Marital status			**Farming Experience**		
Single	45	14.9	1-10	32	10.6
Married	220	73.1	11-20	98	32.6
Divorced	22	7.3	21-30	167	55.5
Widow/widower	14	4.7	31-40	04	1.3
Level of education			**Mean**	**26**	
Primary	99	32.9	**Source of Capital**		
Secondary	150	49.8	Banks	55	18.3
Tertiary	41	13.6	Friends/relatives	69	22.9
Non formal	11	3.7	personal savings	100	33.2
Household size			Co-operatives society	34	11.3
1-4	110	36.5	Other	43	14.3
5-8	179	59.5	**Source of land**		
9-12	07	2.3	Inheritance	193	64.1
13-16	05	1.7	Lease/rent	14	4.7
Mean	**7**		Gift	23	7.7
Occupation			Purchase	26	8.6
Farming only	199	66.1	Pledge	45	14.9
Farming and others	102	33.9	**Source of labor used**		
Farm Size			Family	125	41.5
0.1-1.0	105	34.9	Hired	101	33.6
1.1-2.0	125	41.5	Both	75	24.9
2.1-3.0	33	10.9			
3.1 & above	38	12.6			
Mean	**1.8**				
Extension contacts					
1-2	51	16.9			
3-4	234	77.7			
5-6	12	3.9			
7& above	04	1.3			
Mean	**3.7**				

Source: Field survey data, 2022. Compiled by author.

The majority of sweet potato farmers, 66.1%, were simply engaged in farming operations, while 33.9% were engaged in farming and other associated professional endeavors. This means that the sweet potato growers make a living through farming and other occupations. These involved activities enable them to support their individual family members and dependents (Korji & Kebede, 2017). About 41.5% of the farmers had farm sizes ranging from 1.1 to 2.0 hectares, with a mean hectare size of 1.8. This means that the farmers cultivated less than 2 hectares of land and that the acreage used for sweet potato production is quite limited. This was also to be expected given that land in rural agricultural regions is typically fragmented and insufficient for big cultivations (Lemessa et al., 2019).

Approximately 16.9% of farmers had 1-2 physical encounters with extension agents, while the majority, 77.7%, had 3-4 physical contacts. The average number of extension contacts was four, implying that sweet potato farmers had modest interactions with extension agents. These physical connections assist the farmers in learning practical and innovative experiences related to sweet potato cultivation. This was intended to increase crop yield and farm revenue for potato growers in general (Mamaru &Lemma, 2022). According to the data, the majority of farmers, 59.8%, do not belong to cooperative groups, while 40.2% do. This means that the farmers' smaller minority profited from their cooperative groupings in terms of access to knowledge, farm inputs, financial facilities, and other services. Belonging to a cooperative group improves farmers' farming efforts in general (Makuvaro et al., 2018).

The majority of farmers (60.5%) attended workshops/trainings three to four times every farming season. Approximately 35.9% participated 1-2 times. The mean participation score of 3.3 indicates that the sweet potato growers attended at least three agricultural workshops/trainings. The training helps with information gathering and a proper grasp of agriculture production methods (Mamaru &Lemma, 2022). The bulk of the farmers, 55.5%, have been producing sweet potato for 21-30 years, implying that the farmers have extensive farming expertise. The average agricultural experience was 26 years, indicating that sweet potato farmers were well-versed in farm management and production activities. Experienced farmers often outdo inexpert farmers (Oniah, 2019). Farmers obtained finance through a variety of channels, 18.3% obtained from banks, 22.9% got from friends/relatives, 33.2% obtained capital from personal savings, and 11.3% through co-operative societies. This typically suggests that the majority of farmers saved money to begin producing potatoes.

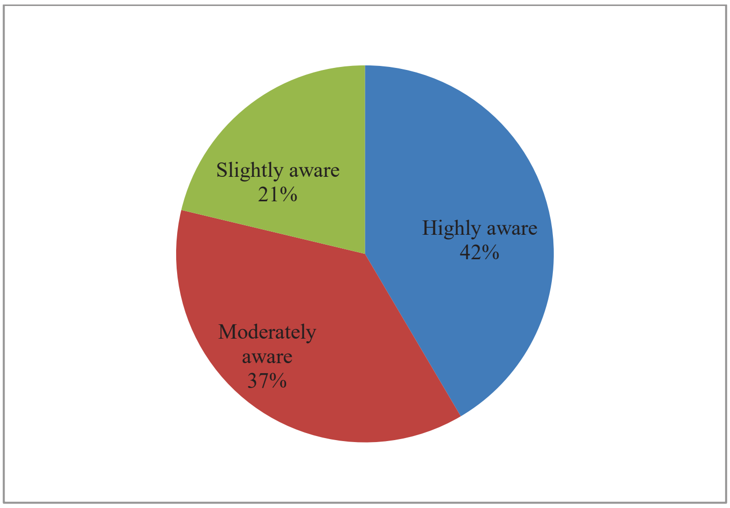


Fig. 2. The level of awareness of sweet potato farmers to climate change

Source: Field survey data, 2022. Compiled by author.

According to the table, farmers obtained their lands in a variety of ways: 14.9% obtained their land by promise, 8.6% through purchase, 7.7% through gifts, 4.7% through rent/lease, and 64.1% through inheritance. This means that the vast majority of farmers inherited their land. The rural areas are dominated by inherited rural lands (Prakash et al., 2021). About 41.5% of farmers employed family labor, 33.6% hired labor, and 24.9% used combined family and paid labor. This means that, in general, the majority of farmers employed family labor rather than hired labor, which might be attributed to the higher wages paid to hired laborers in rural regions. In most situations, hired labor is employed to supplement family labor (Roessali et al., 2019).

According to the data, 21.3% of farmers were barely aware of climate change; this might be due to a lack of information on climate change and fewer assaults or impacts on crop output (Ogbuabor &Egwuchukwu, 2017). Again, 37.2% were fairly informed, and 41.5% were extremely aware. This suggests that most sweet potato producers were aware of climate change (Figure 2).

This could be due to the hazards and destruction experienced in their farm operations and activities during the cropping year (Ogunbode, 2021). Again, the farmers opined being aware of climate change via agricultural workshops, trainings, seminars, cooperative unions, and other media sources. Awareness of climate change propels crop farmers to embrace agricultural climate smart practices and other innovative farming methods in mitigating adverse effects of climate change. This increases farm yield, enhances farm productivity, and farm income of the farmers (Diriba et al., 2019; Onyekuru &Marchant, 2017).

The land productivity of sweet potato farmers is shown in Table 2.

Table 2. Land productivity of sweet potato farmers

Size of land	Land productivity	Frequency	Percentage	Minimum productivity	Maximum productivity	Standard variation
0.1-1.0	1583.730 ha	105	34.9	1001.35 ha	1893.04 ha	0.14
1.1-2.0	1769.831 ha	155	51.5	1293.61 ha	1983.50 ha	1.91
2.1-3.0	1263.824 ha	41	13.6	1102.32 ha	1579.81 ha	0.53
Mean	15.3401 ha	-	-	-	-	-
Total	4617.385 ha	301	100.0	3397.28 ha	5456.35 ha	2.58

Source: Field survey data, 2022. Compiled by author.

Results from the table show that about 35% of the farmers recorded an estimated land productivity of 1583.730 hectares from 0.1-1.0 hectares of land. This implies an improvement in land productivity in the state looking at the size of land from which the value was estimated. About 14% had an estimated land productivity of 1263.824 hectares from 2.1-3.0 hectares of land; this implies a decrease in land productivity of about 79.8%. The decrease could result from an inability of the sweet potato farmers to effectively utilize their available land for cultivation (Oti, 2017). This could also result from both internal factors (production constraints) and external factors such as (climate change incidences, etc.) (Oti et al., 2021).

The majority of the farmers, 52%, had an estimated land productivity of 1769.831 hectares from 1.1-2.0 hectares. This implies that farmers who cultivated in this piece of land produced the highest land productivity relative to the other two hectares of land. This could mean that the sweet potato farmers utilized their limited and available resources (inputs) to efficiently maximize output and/ or farm returns (Abdurahman et al., 2017). The mean and total productivity of the land was estimated at 15.3401 hectares and 4617.385 hectares respectively. This suggests that sweet potato land productivity in the state could be enhanced if farmers could maximize their inputs and resources effectively (Prakash et al., 2021).

The effects of climate change on sweet potato production are shown in Table 3.

Table 3. Effect of climate change on sweet potato production

Variable	Linear	Semi-log	Double-log	Exponential
Constant	30.0421 (0.3103)	7.0145 (4.1189)***	0.6106 (1.4721)	7.5194 (1.5021)*
Temperature (X_1)	-4.0150 (-4.0211)***	-0.9409 (-1.5130)*	-0.78955 (-2.5071)**	-20.5388 (-2.2023)**
Rainfall (X_2)	-0.6136 (-3.1124)***	-6.0630 (-1.0544)	-6.7418 (-2.4201)**	-0.9831 (-1.4322)
Number of rainy days (X_3)	-5.6030 (-2.0167)**	-10.3360 (-1.0412)	-4.9705 (-1.0002)	-14.5219 (-0.4150)
Evaporation rate (X_4)	0.3217 (1.0432)	0.7715 (2.1101)**	22.7982 (4.5402)***	0.8089 (4.4717)***
Sunshine hours (X_5)	18.0254 (3.5503)***	0.9262 (1.7512)*	24.4139 (0.5411)	0.8821 (3.5025)***
Relative humidity (X_6)	8.1203 (4.8036)***	0.8266 (1.0461)	40.3515 (1.2271)	7.4201 (0.9693)
R^2	0.8214	0.7641	0.7601	0.7971
F- ratio	42.1032***	10.3011***	21.2403***	15.8221***

Significant ***1%, **5% and *10%

Source: Field survey data, 2022. Compiled by author.

Data from Table 3 shows the true impact of climate change on sweet potato output. The linear functional form was used to determine this, considering the number of significant variables, greatest F-value, and R^2. The R^2 value of 0.8214 revealed that the climatic variables completely explained 82.14% of the overall fluctuations in sweet potato yield.

Temperature was negative and substantial at 1%, showing that rising temperatures reduce sweet potato yield. Increased warmth promotes the growth of soil micro-organisms, which spawn crop insect pests and diseases, impacting crop outputs, income, and long-term potato production. High temperatures harm sweet potato seedlings and phases of growth and development, reducing plant stature and deep root extension and resulting in low growth and yield (Oti et al., 2021).

Rainfall was negative and statistically substantial at 1%, showing that more rainfall reduces sweet potato crop yields. Increased rainfall poses possible threats to sweet potato crop production by generating intensive soil erosion resulting in stunted and destructive root and shoot growth. Increased rainfall degrades planted sweet potato crops, lowering yield and economic value (Asrat &Simane, 2018). More rainfall induces land flooding which limits sweet potato crop yield and worsens the state's local food security crisis (Elia et al., 2017).

The number of rainy days was negative and important at 5%, meaning that an increase in the number of rainy days affects sweet potato output via excessive land swamping and destruction of vegetative topsoils (Oti, 2017). It also reduces the nutrient capacity of the soil, making it less productive (Ifeanyi-Obi &Asiabaka, 2014). A rise in the number of rainy days encourages the spread of numerous plant and crop diseases impacting sweet potato crop output (Fierros-Gonzale &Lopez-Feldman, 2021).

Sunlight hours were positive and statistically beneficial at 1%, meaning that an increase in sunlight hours improves sweet potato yield. Sunshine is essential for successful crop growth and development. It promotes photosynthetic activity in sweet potato plants, resulting in sustainable yield (Spore, 2019). Its importance in crop production cannot be relegated because it serves as a medium for food plants conversion for carbohydrates and encourages soil organisms' microbial activities (Sustrisno, 2023).

Relative humidity was positive and beneficial at 1%, meaning that an increase in relative humidity of 1% will result in an increase in sweet potato output. Relative humidity raises the moisture capacity of sweet potato lands, particularly during dry seasons, leading to greater sweet potato production and a more sustainable output (Sustrisno, 2023). Relative humidity improves water relation in plant formation, leaf growth, photosynthesis, pollination of plants, and economic production. It promotes seed development and germination while also improving soil moisture delivery (Makuvaro et al., 2018). However, the overall findings of the study reveal that climate change had both positive and negative impacts on sweet potato production in the study area.

The factors influencing sweet potato production of farmers are shown in Table 4.

Table 4. Factors influencing sweet potato production of farmer

Perceived Constraints	*Frequency	Percentage
High cost and low availability of labor supply	264	87.7
Poor knowledge in sweet potato farming	256	85.0
Inadequate farming lands	260	86.4
Poor extension access and services	152	50.5
Land fragmentation	247	82.1
Problem of storage facility	155	51.5
Inadequate capital	301	100.0
Inadequate information concerning climate change	265	88.0
Pests and disease attacks	261	86.7
High cost of inputs materials	301	100.0

*Multiple Responses

Source: Field survey data, 2022. Compiled by author.

The data from the table shows multiple responses indicating that the sweet potato farmers pointed out more than one perceived constraint influencing their sweet potato production. About 87.7% of the farmers observed high cost and low availability of labor supply; this means that there is shortage of labor supply coupled with the high cost charged by the laborers (Tadese et al., 2017). About 85.0% of the farmers noted poor knowledge in sweet potato farming; this implies that the level of illiteracy exhibited by the farmers affected their production outputs. 86.4% of the farmers acceded to inadequate farming lands, this implies that there is limited and inadequate lands which inhibits extensive cultivation (Roessali et al., 2019).

Poor extension access and services were indicated by 50.5% of the farmers. This implies that extension access and services were not sufficient and this affected both technical and practical innovations of potato production in the state (Tessema et al., 2020). About 82.1% of the farmers lamented about land fragmentation issues. This implies that ownership of lands in piecemeal distorted large-scale cultivation of sweet potatoes (Ugochukwu et al., 2019). 51.5% of the farmers complained of problems of storage facility, this implies that the preservation of sweet potato in the state was perceived as a problem influencing sweet potato production of farmers. This could be related to the issue of climate change (high temperatures) interfering with sweet potatoes storage (Oti et al., 2021).

Inadequate capital was observed by all the sweet potato farmers. This emphasizes the significance of capital in farm production activities and operations (Korji &Kebede, 2017). Inadequate information concerning climate change was indicated by 88.0% of the farmers. This means that inaccessibility of climate change information services influences sweet potato production negatively (Upadhyay et al., 2020). Lack of access to climate change information exposes farmers to adverse impacts of climate change. About 86.7% of the farmers indicated pests and disease attacks; this implies that the incidence of pests and diseases were felt by the sweet potato farmers.

Pests and disease attacks cause mayhem and destruction of planted potato crops (Wassihun et al., 2019). Conclusively all the sweet potato farmers complained of high cost of input materials; this implies that the rising cost of input materials significantly affected sweet potato production of farmers, which means that farmers were unable to get as much needed inputs as expected due to rising cost in input prices (Xiao et al., 2022; Zenbaba, 2021).

Conclusion

The findings of this study reveal that sweet potato farmers in Ebonyi State, Nigeria were young, predominantly male, married, experienced, and relatively educated to carry out their farming operations. The majority of the sweet potato farmers were aware of climate change disturbances with lesser percentages being moderately and slightly aware. The mean and total productivity of the land was estimated at 1.53401 hectares and 461.7385 hectares. High cost and low availability of labor supply, poor knowledge in sweet potato farming, inadequate farming lands, pests and disease attacks, inadequate capital, and high cost of input materials constrained sweet potato production in the state.

The study found that climatic variables such as temperature, rainfall and number of rainy days negatively influenced sweet potato production while sunshine and relative humidity influenced sweet potato production positively. However, with these findings, it is expected that policy makers in Nigeria will find this study a good reference material in formulating new policies and adjusting existing ones to ensure self-sufficiency in sweet potato production. Farmers should be encouraged to seek out climate change information early, to be favorably disposed to mitigate its negative effects on sweet potato production. Farmers should be encouraged to participate in agricultural workshops, trainings, and seminars to acquire new knowledge on modern agricultural practices and methods and climate change mitigation.

References

Abdurahman, A., Griffin, D., Elphinstone, J., Struik, P.C., Schulz, S., Schulte-Geldermann, E., Sharma K. (2017). Molecular characterization of Ralstoniasolanacearum strains from Ethiopia and tracing potential source of bacterial wilt disease outbreak in seed potatoes. *Plant Pathology*, 66, 826-834.

Akande, A., Costa, A.C., Mateu, J., Henriques R. (2017). Geospatial analysis of extreme weather events in Nigeria (1985-2015) using self-organising maps. *Advances in Meteorology*, 11, 8576150. https://doi.org/10.1155/2017/8576150.

Alemu, I.D., Addisu M.T. (2021). Adoption of potato varieties in West and Kellem-Wollega Zones, Ethiopia. *Plant Science*, 4, 912-916. https:doi.org/10.14719/pst.2021.8.4.1251.

Arora, N.K. (2019). Impact of climate change on agriculture production and its sustainable solutions. *Environmental Sustainability*, 2, 95-96.

Asfew, M., Bedemo A. (2022). Impact of climate change on cereal crops production in Ethiopia. *Advances in Agriculture*, 2208694, 1-8. https://doi.org/10.1155/2022/2208694.

Asrat, P., Simane B. (2018). Farmers' perception of climate change and adaptation strategies in Dabus watershed, North-West Ethiopia. *Ecological Processes*, 7(7), 1-13.

Bassey, E.E., Effiong, U.A., Aniezi N.F. (2019). Field evaluation of elite' sweet potato (Ipomoea batatas (L.) Lam) varieties in humid rainforest of Calabar, Nigeria. *Asian Journal of Biological Sciences*, 12(4), 779-785. doi:10.17311/ajbs.2019.779.785.

Boansi, D. (2017). Effect of climatic and non-climatic factors on cassava yields in Togo: Agricultural policy implications. *Climate*, 5(2), 28-36. https://doi.org/10.3390/cli5020028

Chikezie, C., Ibekwe, U.C., Ohajianya, D.O., Orebiyi, J.S., Ibeagwa O.B. (2019). Vulnerability of food crop farmers to climate change in South Eastern Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology*, 30, 1-8.

Diriba S., Damie, M., Alemayehu M. (2019). Climate change adaptation strategies in response to food insecurity: the paradox of improved potato varieties adoption in eastern Ethiopia. *Food Science and Technology*, 5, 1-15.

Ebele, N.E., Emodi N.V. (2016). Climate change and its impact in Nigerian economy. *Journal of Scientific Research & Reports*, 10(6), 1-13. http://www.journaljsrr.com/index.php/JSRR/article/view/21917/40737.

Elia, E. (2017). Farmers' awareness and understanding of climate change and variability in Central arid Tanzania. *University of Dares Salaam Library Journal*, 12(2), 124-138.

Esan V.I., Omilani O.O. (2018). Assessment of four Sweet Potato (Ipomoea batatas L.) varieties for adapatibility and productivity in Iwo, Osun State. *Asian Journal of Agricultural and Horticultural Research*, 1(1), 1-8.

FAO, (2022). Statistical dataset on climate change and agricultural production. Food, Agriculture and Organization Rome Italy.

Feleke, A., Regasa, G., Muche M. (2019). Factors influencing adoption of improved potato (Belete) variety: Evidence from Ethiopian smallholder farmers. *Agraarteadus*, 30(2), 85-92.

Fierros-Gonzalez, I., Lopez-Feldman A. (2021). Farmers' perception of climate change: A review of the literature for Latin America. *Frontiers in Environmental Science*, 9, 1-7.

Fischer, G., Tubiello, F.N., van Velthuizen, H., Wiberg, D.A. (2017). Climate change impacts on irrigation water requirements: effects of mitigation, 1990-2080. *Technological Forecasting and Social Change*, 74, 1083-1107.

Gray, E. (2021). Climate change and its environmental impacts on crop growth; NASA's Earth Science News Team: Washington, DC, USA.

Haider, H. (2019). Climate change in Nigeria: Impacts and responses. K4D Helpdesk Report 675. Brighton, UK: Institute of Development Studies.

Ifeanyi-Obi, C.C., Asiabaka C.C. (2014). Impacts of climate change on sustainable livelihood of rural dwellers in southeast Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 10(3), 71-77.

Keba, A. (2019). Review on adoption of improved agricultural technologies in Ethiopia. *International Journal of Health Economics and Policy*, 4, 11-19.

Korji, D., Kebede B. (2017) On farm demonstration of adapted irish-potato (SolanumTuberosum) in Highlands of Guji zone, Oromia Region, Ethiopia. *Academy Research Journal of Agricultural Science*, 5, 514-520.

Lemessa, S.D., Yismaw, M.A., Daksa, M.D., Dechassa N. (2019). Adoption spells of improved potato varieties by smallholder farmers in eastern Ethiopia. *Problems of World Agriculture*, 19(2), 103-118. doi:10.22630/PRS.2019.19.2.27.

Makuvaro, V., Walker, S., Masere, T.P., Dimes J. (2018). Smallholder farmer perceived effects of climate change on agricultural productivity and adaptation strategies. *Journal Arid Environments*, 152, 75-82. doi:10.1016/j.jaridenv.2018.01.016.

Mamaru, T., Lemma T. (2022) Empirical review on determinants of improved potato technology adoption in Ethiopia. *Research and Development*, 3, 185-191. doi: 10.11648/j.rd.20220303.17.

Mariem, S.B., Soba, D., Zhou, B., Loladze, I., Morales, F., Aranjuelo I. (2020). Climate change, crop yields, and grain quality of c3 cereals: A meta-analysis of [CO_2], temperature, and drought effects. *Plants*, 10(6), 1052-1071. https://doi.org/10.3390/plants10061052.

Ogbuabor, J.E., Egwuchukwu, E.I. (2017). The impact of climate change on the Nigerian economy. *International Journal of Energy Economics and Policy*, 7(2), 217-223. https://dergipark.org.tr/en/download/article-file/361739.

Ogunbode, T.O. (2021). Climate change scenario in Nigeria: local perceptions and the way forward. International *Journal of Hydrology*, 5(2): 84-85.

Oniah, M.O. (2019). Effects of climate influence on sweet potato (Ipomeabatatas) production in Cross River, Nigeria. *American Journal of Environmental and Resource Economics*, 4(3), 16-120. doi:10.11648/j.ajere.20190403.15.

Onyekuru, N.A., Marchant R. (2017). Climate change perception, awareness and adaption decision among forest communities in Nigeria. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension*, 16(3), 51-62. doi: https//dx.doi.org/10.4314/as.v16i3.8.

Oti, O.G. (2017). Effects of livelihood factors on climate change adaptation and resource use efficiency of rural farm households in Southeast Nigeria. Unpublished PhD Thesis submitted to the Department of Agricultural Economics, University of Nigeria, Nsukka.

Oti, O.G., Okoye, C.U., Obasi I.O. (2021). Awareness and perception of climate change among farmers in Nigeria: Implications for food security. *Nigerian Agricultural Journal*, 52(2), 164-173.

Prakash, B., Kalyani, M.T., Gautam, D.M., Arjun K.S. (2021). Storability of sweet potato genotypes under ordinary ambient storage conditions. *Journal of Agricultural Science* 32(2), 214-224. doi:10.15159/jas.21.20.

Rettie, F.M., Gayler, S.K.D., Weber, T., Tesfaye, K., Streck T. (2022). Climate change impact on wheat and maize growth in Ethiopia: A multi-model uncertainty analysis. *PLoS ONE* 17(1), e0262951. https://doi.org/10.1371/journal.pone.0262951.

Roessali, W., Purbajanti, E.D., Dalmiyatun T. (2019). The adoption behaviour and its influenced factors of true shallot seed technology in Central Java. *Earth and Environmental Science,* 250, 012072.

Spore, (2019). Weather forecasts: Helping farmers win their battle against climate change. Scaling a higher priority for agriculture. CTA No.191, 2019.

Sustrisno, J. (2023). The impact of climate change on the production of cassava and sweet potato in indonesia. IOP Conference series earth and Environmental Science, 1180(1), 012038. doi:10.1088/1755-1315/1180/1/012038.

Tadese, Y., Conny, J.M., Rogier, P.O., Paul C.S. (2017). Tracing the seed: seed diffusion of improved potato varieties through farmers' networks in Chencha, Ethiopia. *Experimental Agriculture*, 53, 481-496.

Tessema, L., Mohammed, W., Abebe T. (2020). Evaluation of potato (Solanumtuberosum L.) varieties for yield and some agronomic traits. Open Agriculture, 5: 63-74.

Ugochukwu, O.R., Augusta, N.C., Chinonso, E. C., Nwajiuba, A., Judith, O.C., Ohalete, P. & Iyke U.U. (2019). Climate change adaptation in Nigerian agricultural sector: A systematic review and resilience check of adaptation measures. *AIMS Agricultural and Food*, 4, 967-1006.

Upadhyay, N., Ghimire, Y.N., Acharya, Y., Sharma B. (2020). Adoption of improved potato varieties in Nepal. *Black Sea Journal of Agriculture*, 3(2), 139-145.

Wang, J., Vanga, S.K., Saxena, R., Orsat, V., Raghavan V. (2018). Effect of climate change on the yield of cereal crops: A review. *Climate*, 6(2), 41-50; https://doi.org/10.3390/cli6020041.

Wassihun, A.N., Koye, T.D., Koye A.D. (2019). Analysis of technical efficiency of potato (Solanumtuberosum L.) production in Chilga District, Amhara National Regional State, Ethiopia. *Economic Structures,* 8, 34-41. https://doi.org/10.1186/s40008-019-0166-y.

Xiao, Y., Zhu, M., Gao S. (2022). Genetic and research on sweet potato for sustainable food and nutritional security. *Genes*, 13(10), 1833. doi: 10.3390/genes13101833.

Zenbaba, O.S. (2021). Empirical review on determinants of potato and onion production technology packages adoption in Ethiopia. *Journal Agricultural Science Food Technology*, 7(3), 285-291. doi: https://dx.doi.org/10.17352/2455-815X.000121.

For citation:

Osuji E., Igberi Ch., Osang E., Tim-Ashama A., Nwachukwu E. (2023). Climate Change and Sweet Potato Production; Empirical Insights from Ebonyi State, Nigeria. *Problems of World Agriculture*, 23(3), 61-73; DOI: 10.22630/PRS.2023.23.3.12

Informacje dla autorów artykułów zamieszczanych w Zeszytach Naukowych Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie Problemy Rolnictwa Światowego

1. W Zeszytach Naukowych Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie Problemy Rolnictwa Światowego publikowane są oryginalne prace naukowe, zgodne z profilem czasopisma, w języku polskim i angielskim.
2. Zaakceptowane przez redaktora tematycznego artykuły zostaną przekazane do recenzji do dwóch niezależnych recenzentów z zachowaniem zasad anonimowości („double-blind review proces"). W przypadku artykułów napisanych w języku kongresowym, co najmniej jeden z recenzentów będzie afiliowany w instytucji zagranicznej. Lista recenzentów jest publikowana w zeszytach naukowych i na stronie internetowej czasopisma.
3. Recenzja ma formę pisemną kończącą się jednoznacznym wnioskiem co do dopuszczenia lub nie artykułu do publikacji (formularz recenzji znajduje się na stronie internetowej czasopisma).
4. W celu zapobiegania przypadkom „ghostwriting" oraz „guest authorship" autorzy wypełniają oświadczenia (druk oświadczenia znajduje się na stronie internetowej czasopisma).
5. Autor przesyła do redakcji tekst artykułu przygotowany według wymogów redakcyjnych (wymogi redakcyjne znajdują się na stronie internetowej czasopisma). Autor ponosi odpowiedzialność za treści prezentowane w artykułach.
6. Pierwotną wersją czasopisma naukowego jest wersja elektroniczna, która jest zamieszczona na stronie internetowej czasopisma.
7. Publikacja artykułów jest bezpłatna.

Adres do korespondencji

Redakcja Zeszytów Naukowych Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie Problemy Rolnictwa Światowego
Szkoła Główna Gospodarstwa Wiejskiego w Warszawie
Instytut Ekonomii i Finansów
Katedra Ekonomii Międzynarodowej i Agrobiznesu
ul. Nowoursynowska 166, 02-787 Warszawa
tel.(22) 5934103, 5934102, fax. 5934101
e-mail: problemy_rs@sggw.edu.pl

prs.wne.sggw.pl

Information for Authors of papers published in Scientific Journal Warsaw University of Life Science – SGGW Problems of World Agriculture

1. The Scientific Journal of Warsaw University of Life Science – SGGW Problems of World Agriculture, publishes scientific papers based on original research, compliant with the profile of the journal, in Polish and English.
2. The manuscripts submitted, accepted by the Editor, will be subject to the double-blind peer review. If the manuscript is written in English at least one of the reviewers is affiliated with a foreign institution. The list of reviewers is published in the journal.
3. The written review contains a clear reviewer's finding for the conditions of a scientific manuscript to be published or rejected it (the review form can be found on the website of the journal).
4. In order to prevent the "ghostwriting" and "guest authorship" the authors are requested to fill out and sign an Author's Ethical Declarations (the declaration form can be found on the website of the journal).
5. Authors have to send to the Editor text of the paper prepared according to the editorial requirements (editorial requirements can be found on the website of the journal). Author is responsible for the contents presented in the paper.
6. The original version of the scientific journal issued is a on-line version. An electronic version is posted on line on the journal's website.
7. Submission of papers is free of charge.

Editorial Office:
Scientific Journal Warsaw University of Life Science: Problems of World Agriculture / Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie Problemy Rolnictwa Światowego
Warsaw University of Life Sciences-SGGW
Institute of Economics and Finance
Department of International Economics and Agribusiness
166 Nowoursynowska St.
02-787 Warsaw, Poland
Phone: +48 22 5934103, +48 22 5934102, fax.: +48 22 5934101
e-mail: problemy_rs@sggw.edu.pl

prs.wne.sggw.pl