Improving Food Security and Nutrition through Agroecology: The Role of Social Reproduction and Agency

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Abstract

Agroecology is increasingly discussed and promoted as a tool for improving the status of food and nutrition among smallholder farmers in various parts of the world. However, the role of agroecology in realizing food security goal in sub-Sahara ran Africa appear to be contention. Critics suggest that agroecology may not be able to address the sub-Sahara African nutrition and development challenges in the long term because it constitutes a barrier to modernization, locking farmers in a non-productive traditional agriculture and poverty trap. We claim that the social and power dimensions intrinsically linked to an agroecology-based – or in fact in any - intensification strategy appear to be ignored in the discussion and research on agroecology in sub-Sahara Africa. Transitioning to agroecology, even at the farm level also transforms farming households' social and political characteristics, thereby affecting their overall food and nutrition status. Using primary survey data from rural Nigeria, this paper uncovers which pathways of causalities exist between agroecology and Food Security and Nutrition (FSN) and quantitatively assesses the moderating effect of physical, household, and social reproduction on the relationship between agroecology and FNS. We anchor our analysis within feminist economics, more specifically making use of the concepts of reproduction, and agency in our analysis. We consider FNS as a productive goal of the household, linked to several other reproductive dimensions. The concept of reproduction, found in feminist economics, is a useful innovative lens to empirically address the dimension of agency for food security and Nutrition among farming households. Given the strong constraints for the participation of smallholders in the formal production economy, investigating how else they achieve to maintain themselves with alternative systems is crucial for food security in rural areas in Africa.

Keywords: Sub-Saharan Africa, agency, agroecology, physical reproduction, smallholders, social reproduction

JEL codes: A14, D60, Q18

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1. Introduction

Beyond the sustainable production practices of which agroecology is characterized, the social and household activities associated with agroecology also create food system territory for agroecology farmers which is less influenced by external agri-industrial forces (Khadse & Rosset, 2017). We propose three pathways through which agroecology influences food security and nutrition: (1) through physical reproduction in the landscape by employing sustaining production practices, (2) through social reproduction by establishing social relations among peers, and (3) through household reproduction by prioritizing family care and consumption of own food production. The last two involve strengthening the agency, and empowerment of vulnerable and marginalized groups thereby addressing power inequalities in food systems (HLPE, 2020). Considerable research has investigated the role of agroecology in improving food security through physical reproduction in the landscape by employing sustaining production practices (Altieri, Funes-Monzote, & Petersen, 2012; Nyantakyi-Frimpong, Mambulu, Bezner Kerr, Luginaah, & Lupafya, 2016; Oteros-Rozas, Ravera, & García-Llorente, 2019) although literature thus far reveals mixed evidence. For instance, Pretty, Morison, and Hine (2003) conclude from an analysis of 208 projects among 8.98 million farmers and on 28.92 million hectares that agroecology practices influenced food security and nutrition. In contrast, Rogé et al. (2017) observed no significant difference in farm productivity between agroecology and non-agroecology farmers, while Mugwanya (2019) concluded that agroecology could lock farmers in a non-productive traditional agriculture and poverty trap.

In contrast to the large body of literature on agroecology and sustainable agricultural production, research on how agroecology influences food security and nutrition through social and household reproduction is sparse. There exists little or no empirical study, within the knowledge of the authors, investigating these pathways in literature. Therefore, this present research contributes to the existing study in three ways. First, as emphasized above, although many studies have empirically investigated the relationship between agroecology and food security; the results have been mixed, highlighting the need for further empirical study to establish coherence in literature. Second, we are currently not aware of any available literature that has empirically investigated the social and household pathways through which agroecology influences food security and nutrition. Our third contribution regards our focus on women farmers, whose agency and empowerment deficiencies warrants further investigation

We used the term food security to refer to a condition that exists when "people do not have adequate physical, social or economic access to food" (World Food Summit, 1996). We also use the term agroecology to refer to a "set of farming practices that attempt to mimic natural systems through in-depth knowledge of crop, insect and disease ecology, increased agro-biodiversity, and attention to interactions with adjacent natural landscapes" (Nyantakyi-Frimpong, et al, 2016, p.2). Social reproduction describes the continuation and maintenance of existing social relations among agroecology farmers (Doob, 2003). Although there is no single comprehensive household economic theory, several explicit theories on household reproduction centered on the analyses of the decisions made by households and the criteria by which wealth is divided between consumption and production. In that line, household reproduction activities consist of investments in activities that ensure that household members are nourished. This can be achieved in two ways; first by producing enough food needed by household members, or, second, by engaging in productive or market activities to the end that the proceeds from the market are used to maintain the household. Substantial evidence from sub-Saharan Africa suggests that women who spend time learning about household reproduction activities such as cooking, nutrition, and hygiene generally have a more significant concern with nutrition and diet quality, child education and also have a greater tendency to channel resources and spending on food than on non-food items (Hoddinott & Haddad, 1995; Santoso et al., 2019).

In this setting, the objective of this paper is to empirically confirm the physical reproduction pathways through which agroecology improves food and nutrition status of smallholder farmers, identify other pathways which have thus far been silent in literature, and demonstrate the interrelationships between these variables.

2.0 Conceptual framework and hypothesis development

We commenced the development of the framework linking agroecology to food security by conducting series of expert interviews with local agricultural extension officers and agroecology facilitators in the community. We conducted these interviews to grasp the real problems affecting smallholder farmers. Additionally, we conducted a systematic literature review to derive indicators to assessing the reproduction goals of farmers. The outcome of the expert interviews and research literature showed that political and economic structural issues primarily determine the extent to which smallholder farmers achieve agency for food and nutrition security. The experts agreed that smallholder farmers do not only seek monetary goals but reproduction goals. However, their comments show that government does not proportionately support small-scale farmers in the area as much as the government supports medium and large-scale farmers. On the other hand, the experts showed that the agroecology farmers in the area are innovative to utilize nature and social capital to enhance productivity and create alternative local market systems.

Figure 2 proposes a framework for understanding direct and indirect links between agroecology, agency, and food and nutrition security. We adopted the framework suggested in Chukwuma, Stephanie, & Nuppenau (2020) because it highlights the linkages of the primary variables included in this study. We develop three testable Pathways (P_i) to reflect the research questions.

P1: what is the effect of smallholder farmers' empowerment on smallholder farmers' food security experience and observed dietary diversity? We hypothesize a positive relationship.

P2: does agroecology influence smallholder farmers' food security experience and observed dietary diversity? We hypothesize a positive relationship.

P3: does empowerment boosts the gains in smallholder farmers' food security experience and observed dietary diversity from agroecology. We hypothesize that agency moderates the relationship between agroecology and smallholder farmers' food security experience and observed dietary diversity.

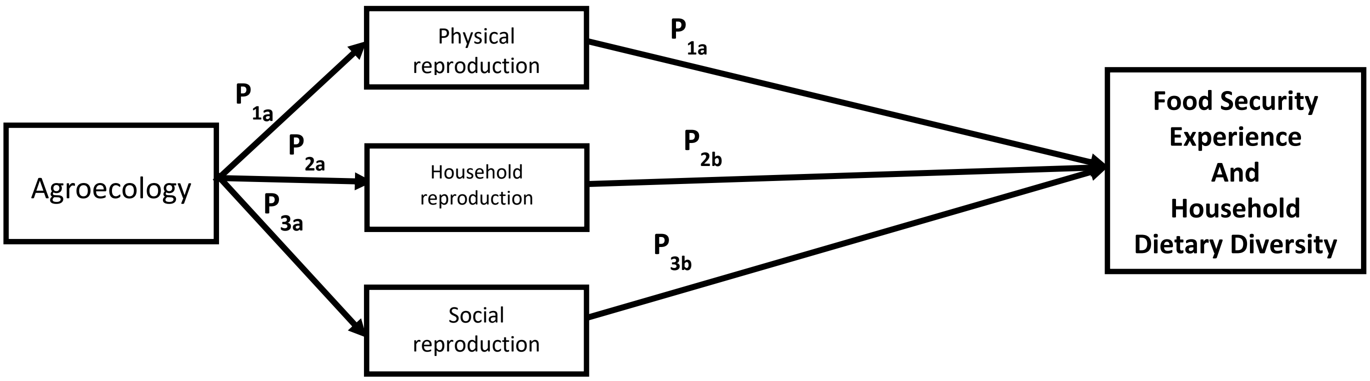

Figure 1. Conceptual framework of the links between agroecology, smallholder farmers' empowerment, and FNS.

Source: (Chukwuma et al., 2020)

The first pathway P1 (Fig. 2) relates to the effect of agroecology on smallholder farmers' food security experience and observed dietary diversity, which we posit operates through physical reproduction activities in the farm such as soil conservation and management and other sustainable cropping patterns. Nyantakyi-Frimpong, et al. (2016) show that agroecology farmers in northern Malawi experience consistent yields because of soil maintenance through legume intercropping, intercropping, and biodiversity conservation. Li et al. (2009: p.1) show that crop combination of legumes and cereals or tuber crops increased crop yields to about 30 to 85%. Zero tillage and biodiversity conservation can lead to soil maintenance and fertility conservation (pathway P_2a). Increased yield through mixed cropping and soil conservation will increase household food availability from own production (pathway P_{1b}) and farm incomes from marketable surplus (pathway P_{1b}). Agroecology provides additional benefits such as the variety of crops and the quality of the crops produced. Information from the expert interview showed that agroecology farmers produce better cassava and maize species in the area, which attracts consistent market demand and patronizes.

The second pathway P2 concerns the role of household reproduction activities (child education, own food production, and production of varieties food crops) in moderating the effects of agroecology on food security and dietary diversity. Substantial evidence from low-income countries shows that smallholder farmers and medium /large scale farmers differ in their preferences for and patterns of resource allocation and spending on food and non-food items, with small-scale farmers, generally having more significant concern with diet quality and nutrition (Kissoly et al., 2020; Mgbenka & Mbah, 2016; Ng'endo, Keding, Bhagwat, & Kehlenbeck, 2015). Farmers who also prioritize their food production as against dependent on the market are better in terms of access to food. Also, smallholder farmers with greater say in production decisions, and better access to production resources are more able to ensure that the agroecology-induced increase in food availability trickles across to family members at the household level (Seymour, Masuda, Williams, & Schneider, 2019). In addition, adoption of agroecological practices such as inter-cropping, organic manure application, and zero tillage reduces pest and weed infestation which in turn encourages labor savings, largely because of reduced plowing frequency and the suppression of weed infestation through intercropping (Calderón et al., 2018). Agroecology farmers might re-allocate the freed-up labor gained through agroecology to household care and leisure or production of food for the family (pathway P_{2b}).

The third pathway P3 hypothesis that smallholder farmers with greater network and information will have better opportunities for input and produce exchange and local market (pathway P3a). Where small-scale farmers have control over income due to improved social status, they will allocate more income to food than to cash crops (pathway P3). Smallholder farmers with a strong social network will also have the avenue to benefit from peer-to-peer knowledge and resource exchange (Faysse, Sraïri, & Errahj, 2012).

3.0 Research methodology

3.1. Study area and data collection

The study area is Umuimo community in the Southeastern zone of Nigeria (Figure 1). In 2016, a group of researchers from the Centre for Agroecology, Water and Resilience, United Kingdom established an agroecology movement in Umuimo community in the Southeastern zone of Nigeria. The aim was to support transition towards agroecology-based farming and food systems. Smallholder farmers were trained on sustainable agroecological farming practices. Participation was voluntary and farmers who participated in this training formed an informal agroecology group independent of the government. In the study area, the government appears to emphasize the production of few cash crops, creating a protectionist food system pattern where cash cropping displaces food crops such as vegetables, beans and yam (Nigerian Organic Agriculture Network, 2018). There are also reports of land grabbing incidences where poor villages and local smallholders were forced to abandon their ancestral land for large-scale cash crop productions (Emenyonu et al., 2017; Picco et al., 2016a). Because the technology employed in the agricultural revolution in the region require substantial amount of capital, only the large few farmers could maximize production hence concentrating power on large farms and in fewer and fewer hands. According to Picco et al. (2016) market system in the region is more of an oligopolistic structure dominated by few actors in the commodity crop chains with little bargaining power on food producers.

The team established a peer-to-peer network among the members of the group (only small-scale farmers) through a registered smartphone application. Through this application and other peer-to-peer meetings and training, the group fostered knowledge sharing and action among themselves, thereby connecting traditional and scientific knowledge to produce food more sustainably. The agroecology group has been reported to identify science-based actions, utilize knowledge systems in new ways, and provide resilience for food systems and ecosystem services in agricultural landscapes of the region despite the future uncertainty of climate change (Emeana, Trenchard, Dehnen-Schmutz, & Shaikh, 2019). Apart from knowledge production, the farmers pool their resources, share land and labor, as well develop local market and crop exchange markets.

In this study, the definition of smallholder farm household follows from FAO (2020). In this regard, a farm household is said to be a smallholder when it manages a land area of less than 5 hectares. To capture only smallholder farm households, we asked a control question on land size at the start of each survey to determine the eligibility of the respondents for the survey.

We collected data for this study between 2020 and 2021 in southeast Nigeria. The study utilized both qualitative and quantitative approaches (mixed method). For the quantitative aspect of the study, we employed a cluster-sampling technique in the selection of respondents for the study. We employed cluster sampling, as the population for the study comprises mutually homogeneous yet internally heterogeneous groups of agroecology and non-agroecology farmers (conventional farmers). As described earlier, in 2016, a team of researchers from the center of agroecology, United Kingdom initiated an agroecology movement in the study area. For the agroecology group, we obtained an aggregated list of agroecology farmers from this team. The list contained 110 farm households. For the non-agroecology farmers, we obtained a list of conventional farmers from the regional headquarters of the Agricultural Development Program (ADP). From this list, we randomly sampled 240 smallholder farm households. In total, we surveyed 350 respondents (comprising of 110 agroecology farmers and 240 non-agroecology farmers). We administered a structured questionnaire jointly to the female and male adult decision-makers in the household. We employed trained enumerators who spoke and understood the local language of the study area to administer the questionnaires in person.

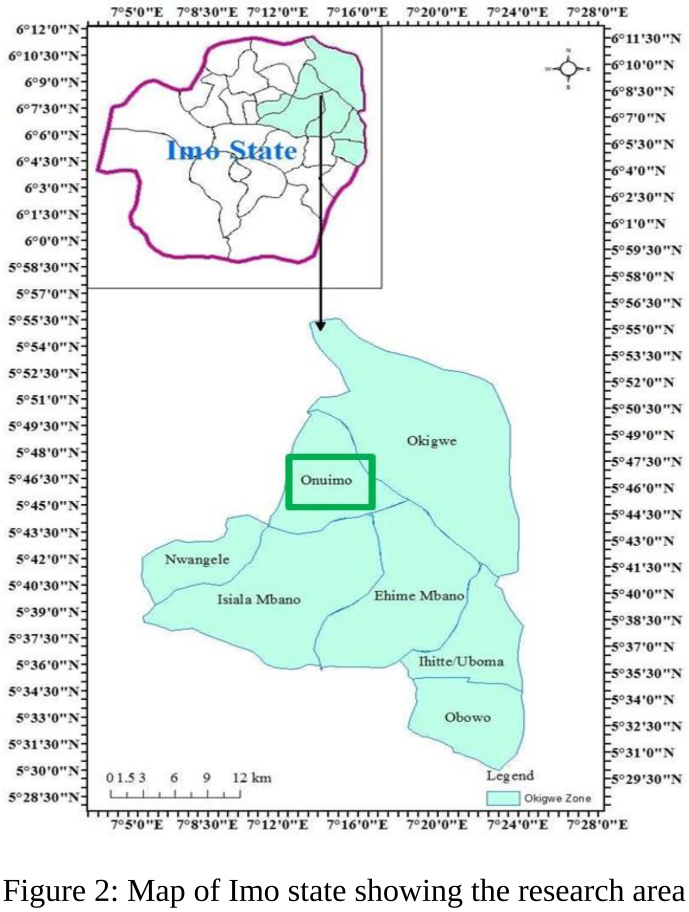

Figure 2: Map of Imo state showing the research area
Source: (Uluocha, Umazi Udeagha, & Duruigbo, 2016)

We used a detailed participant information sheet containing participants' consent forms to obtain consent from each of the adult male and female respondents. We limited identifying information obtained to the questionnaire number and the name of the village. Surveys were conducted with the approval of the Justus Liebig University research board and the German Academic Exchange Service. We used the household questionnaire to elicit data on individual and household demographic characteristics, asset ownership, access to services such as extension, markets, and credit; networking and social capital, and off-farm income-generating activities. A second part of the questionnaire elicited data on Food Security Experience Scale and Household Dietary Diversity. Here we used a seven days' food consumption via recall to capture these variables. A more comprehensive description of the variables can be found in the supplementary material, including the covariates used in the structural equation model.

3.2. Data Analysis

We propose a Generalized Structural Equation Modeling (Gsem) technique to estimate the pathways from agroecology to food and nutrition. The structural equation modeling (SEM) is proposed to capture the latent nature of the variables (agroecology, reproduction, and food and nutrition security). Also, the SEM encompasses a broad array of models from measurement models, factor analysis to the simultaneous equation, making it fit to simultaneously capture the direct and indirect path (Tarka, 2018). The generalized model is preferred as it allows the inclusion of factor-variable notation and count variables (Tarka, 2018), which are the most common ways nutrition and food security variables are measured (Abbade, 2017).

Agroecology was measured using the dichotomous dummy of 0 and 1, where 1 represents farmers belonging to an agroecology group, 0 otherwise. The Food Seucrity and Nutrition (FSN) variable consists of two embedded variables each measuring food security and nutrition security. Food security is generally depicted by the Food security experience scale (Food and Agriculture Organization of the United Nations, 2020). Over the past two decades, there have been major advances on the fundamental measurement of household food security using scales based on the perception or experience reported by the affected individuals. Experience-based food security measurement scales was employed in this study and offer the following advantages: i) it is the only fundamental method that measures directly the phenomenon of interest-based on the food security experience as perceived by the affected individuals; ii) it captures not only the physical but also the psychosocial dimensions of food insecurity; iii) the method can be used for mapping and understanding causes and consequences of food insecurity and hunger using the household as the unit of analysis; iv) data collection, processing and analysis is straightforward and relatively inexpensive, allowing for the decentralization of data collection efforts; v) it may be applied in very diverse sociocultural settings yielding valid and predictable results. The measure consists of 8 questions. Each respondent's answer was scored according to the question items. To include nutrition component in FSN measure, we included the Household Dietary Diversity Scale (HHDS) (Kissoly et al., 2020). The HDDS is included to capture the nutrition component in FNS analysis. The HDDS has been successfully employed as a proxy for nutrition in several studies as indicator of child malnutrition (McDonald et al., 2015); an indicator of nutrient adequacy (Mahmudiono, Sumarmi, & Rosenkranz, 2017); proxy for socioeconomic status (Vhurumuku, 2014). HDDS consists of 12 questions representing 12 food groups consumed by members of the household of which values “0” or “1” are assigned when individuals in the family did not consume or did consume the food groups respectively. A raw score is assigned by calculating the arithmetic sum of all the questions answered in affirmation in botyh the food security experience scale and dietary diversity components.

Econometric approach

The SEM model can be summarized by two simple simultaneous equations. The reduced form of the first equation (Food security and Nutrition as a function of agroecology) written in the vector form as

$Y1 = Xi\beta i + \varepsilon 1$, …………Eqt (1)

Where:

i = included variables

$Y1$ and $\varepsilon 1$ are observed variables measuring Food security and Dietary diversity and the error term for the first equation respectively,

Xi = rxki matrix of the agroecology variable of interest and other covariants

βi is a kix1 vector of the parameter estimates

The second equation (Agency as a function of food security) is given as

$X1 = Zi\beta i + \varepsilon 4$, ………… Eqt (2)

Where:

i = included variables

$X1$ and $\varepsilon 4$ are observed variables measuring agroecology and the error term for the second equation respectively,

Zi = rzki matrix of the reproduction parameters namely physical, social, and household reproduction

βi is a kix1 vector of the parameter estimates

According to Ma and Koenker (2006), because of the recursive nature of between equations 1 and 2, there is a possible correlation of their error terms, therefore, using structural simultaneous equation modeling will produce a more robust estimation than ordinary least square model.
The Zi depicts the mediating variables explaining the relationship between agroecology and food and nutrition security. We conducted a series of expert interviews to choose the appropriate variables for the various dimensions of the reproductive pathways. From the interview data, we identified different variables that capture the dimensions. Because of the nature of the reproductive variable, there is a possibility that the measurement will be made with both random and systematic error, so to isolate the true score in the variables and remove the error, we need to decompose the individual variables (Xi) into the true score (t) and the error (εi)

$Xi = t + \varepsilon i$ ………… Eqt (3)

This is achieved using a factor analysis technique. We used Confirmatory Factor Analysis (CFA). The CFA was chosen instead of the Principle Component Analysis (PCA) as we already specify the measurement model a-priori before looking at the data (no peeking rule), based on information from the expert interviews and field observations. This means we know which indicators are unrelated to which reproductive pathways. The PCA falls short in this case as PCA is purely inductive, moving from data to theory. The included variables and their descriptions are presented in Table 1.

Table 1: Definition and descriptive statistics reproductive activities employed by households

Variables	Description	Mean	Standard deviation
Physical reproduction			
Cultural practices	Number of farming techniques employed by the farmer (Continuous)	3.84	1.97
Soil management effort	Number of oil fertility management measures (Continuous)	2.16	1.38
Time spent on soil mgt	Percent of time spent on soil management (Percent)	28	11.5
Household reproduction			
Family care	Average time spent on household activities (Continuous)	13hrs	3hrs
Own food production	Percentage of crop used for household feeding (percent)	0.42	0.22
Child education	Percentage of school-age children in school (Continuous)	0.79	1.11
Social reproduction			
Organization	Number of organizations belong to (Continuous)	3.41	1.02
Leadership	Leadership position in a group (1 = Yes; 0 = No)	-	-
Financial contribution	Highest contribution in a group (Continuous)	12516	2408
Labor assistance	Labor assistance from group (1 = Yes; 0 = No)	-	-
Land assistance	Free land access from group (1 = Yes; 0 = No)	-	-
Seed assistance	Free seeds from group (1 = Yes; 0 = No)	-	-
Socialization	Time spent socializing with neighbors (Continuous)	0.64	0.77

Source (Field survey (2020)

4.0 Results

4.1. Relationship between agroecology on Food Security and Nutrition

The bi-variant regression results show a positive relationship between being in the agroecology group and food security and nutrition (Table 2). The regression result showed that being in the agroecology group lead to a increase in food security and nutrition experience by 0.497 units while the R Squared value of 0.015 showed that 1.5% variation in food security and nutrition among the smallholder farmers is accounted for by being or not being in the agroecology group.

Table 2: Direct relationship between agroecology and food insecurity

Parameters	Coefficient	Sig	Standard error
Agroecology	0.497	.000	0.217

R Square 0.015. Adjusted R Square 0.012
Dependent variable = Food Security and Nutrition

4.2. Mediating variables

Theoretically, we adopted the three pathways proposed in (Chukwuma et al., 2020) through which agroecology can affect food security and nutrition: physical, social and household pathways. Based on the unobservable nature of these concepts, we adopted the latent variable construct by representing these pathways using the observed variables as listed in Table 1. To test if these variables are appropriate and suitable measures of the three concepts, we adopted the confirmatory factor analysis (CFA) method. Result of the CFA is presented in Table 4.

Table 4: Confirmatory Factor Analysis Result

Parameters	**Coef.**	**P>|z|**	**Std. Err.**
Physical reproduction variables			
Soil management effort (P1)	.7781	0.000	.0643
Time spent on soil management (P2)	4.4335	0.000	.4773
Cultural practices (P3)	.1982	0.000	.0423
Household reproduction variables			
Family care (H1)	.4270	0.000	.0807
Own food production (H2)	.0477	0.008	.0179
Child education (H3)	.4129	0.057	.0592
Social reproduction			
Organization (S1)	7.157	0.149	4.953
Leadership (S2)	1	Constrained	Constrained
Financial contribution (S3)	9219	0.276	8466
Labor assistance(S4)	.8171	0.235	.6878
Land assistance (S5)	6.949	0.138	4.689
Seed assistance (S6)	3.808	0.151	2.650
Socialization (S7)	-1.401	0.255	1.229

In terms of physical reproduction activities, the result of the CFA showed that the three included variables: soil management effort (P1), time spent on soil management (P2), and cultural practices (P3) were statistically significant, meaning that they are good measures of physical reproduction activities and can be used in the structural equation model. Among the three variables, time spent on soil management practices loaded the highest with a coefficient of 4.4, followed by soil management strategies employed by the farmers 0.7. The cultural practices loaded 0.1. For the household reproduction activities, the entire included variables were also found to be statistically significant measures of household reproduction. They include child education, nutrition knowledge, and resistance to commercialization. However, all the social reproduction activities turned out insignificant, suggesting that based on our data; they are not appropriate measures of the social reproduction activities. Therefore, they were not included in the SEM model.

To understand the correlation between the pathways, we estimated the covariance between the three pathways; the result of the covariance (Table 5) showed that the physical reproduction activities have a statistically significant covariance with the household reproduction activities. The coefficient was found to the positive and approximately 1.3. This suggests a positive correlation between activities on the farm and household activities.

Table 5:

Parameters	Coefficient	Sig	Standard error
Cov (Physical, Household)	1.293837	0.000	.2755898
Cov (Physical, Social)	-.0370545	0.149	.025687
Cov (Household, Social)	-.0030146	0.627	.0061

4.3: Indirect effect of agroecology on FSN

Figure 2 and Table 6 reports the SEM estimates of the effect of agroecology on FSN through household and physical reproduction pathways. In the first pathway (the physical reproduction activities pathway) agroecology impacts FSN through soil management practices, time spent on soil management and sustainable cropping practices. In the second pathway (the household reproduction pathways) agroecology impacts FSN through family care, own food production and child education. The first row in Table 6 shows the SEM estimates of the direct effect of agroecology, physical reproduction and household reproduction on food security and nutrition, while the second and third rows report the direct effect of agroecology on physical and household reproduction respectively. The fourth row reports the indirect effect of agroecology on FSN through the physical and household reproduction pathways.

The result of the SEM model also shows that the physical and household reproduction activities have a statistically significant effect on FSN. A percentage increase in the application of the physical reproduction activities in the farm improves food security and nutrition of the farmers by a factor of 0.21. This was found to be statistically significant. Soil management effort (P1) improves food security and nutrition by a factor of, time spent on soil management (P2) improves food security and nutrition by a factor of 0.75, while application of sustainable cultural practices (P3) improve food security and nutrition by a factor of 5.0. These estimates were found to be statistically significant at a 99% confidence level. For the household reproduction activities, a percentage increase in household activities improves food security and nutrition by a factor of 1. Assessment of the individual factors showed that family care (H1) improves food and nutrition security by a factor of 0.66; own food production (H2) improves food security and nutrition by a factor of 0.08 while child education (H3) improves food security and nutrition by a factor of 1.45.

Considering the direct impact of agroecology on achieving the physical and household hold reproduction goals, rows 2 and 3 of Table 6 shows that agroecology improves household activities by a factor of 1, it improves physical reproductive activities by a factor of 2. This means that agroecology has twice the impact it has on household reproduction on the physical reproduction aspect. To understand the indirect effect of agroecology on FSN through the physical and household pathways, we multiply the direct impacts to the physical and household reproduction with the direct impact from the physical and household to food security and nutrition. The indirect effect shows that agroecology improves food security and nutrition through the physical reproduction pathways by a factor of 0.42. This was also found to be statistically significant. Through the household reproduction pathway, the relationship was constrained 1, suggesting a linear relationship through the household pathway. The direct linear relationship estimated using the OLS regression showed a statistically significant relation between agroecology and FSN, however, the direct relationship estimated with SEM model showed a non-statistically significant relationship. The inability of the direct relationship between agroecology and FSN using the SEM to attain significance suggests a perfect mediation of the pathways, meaning that the pathways adopted in these models are the true causal transmission of the effect of agroecology to FSN.

Table 6: The Structural Equation Model Results

Dependent variable	Agroecology	Physical	Household	P1	P2	P3	H4	H5	H6
FSN	0.42 (1.13)	0.21*** (37.74)	1 (constrained)	1 (constrained)	0.75*** (12.21)	5.0*** (0.80)	0.66*** (8.95)	0.08*** (3.09)	1.45*** (7.04)
Physical	2.0*** (10.62)								
Household	1 (constrained)								
FSN		0.42***	1	2	1.5	10	0.66***	0.08***	1.45***

t-statistics values are shown within parentheses,
***, **, and * shows the significance of the coefficient at 1%, 5%, and 10% respectively.

Post estimation test results

Dependent variable	fitted	predicted	R-squared	mc	mc2
p1	-	-	-	-	-
P2	3.782388	.8960545	.2369018	.4867256	.2369018
P3	1.901082	.4098235	.2155738	.4642993	.2155738
H4	1.252407	.0000288	.000023	.0047985	.000023
H5	.4481722	.1211643	.2703522	.519954	.2703522
H6	0.107432	0.165023	.190755	.4367551	.190755

chi2_ms(11) = 151.090 p > chi2 = 0.000

chi2_bs(21) = 511.356 p > chi2 = 0.000

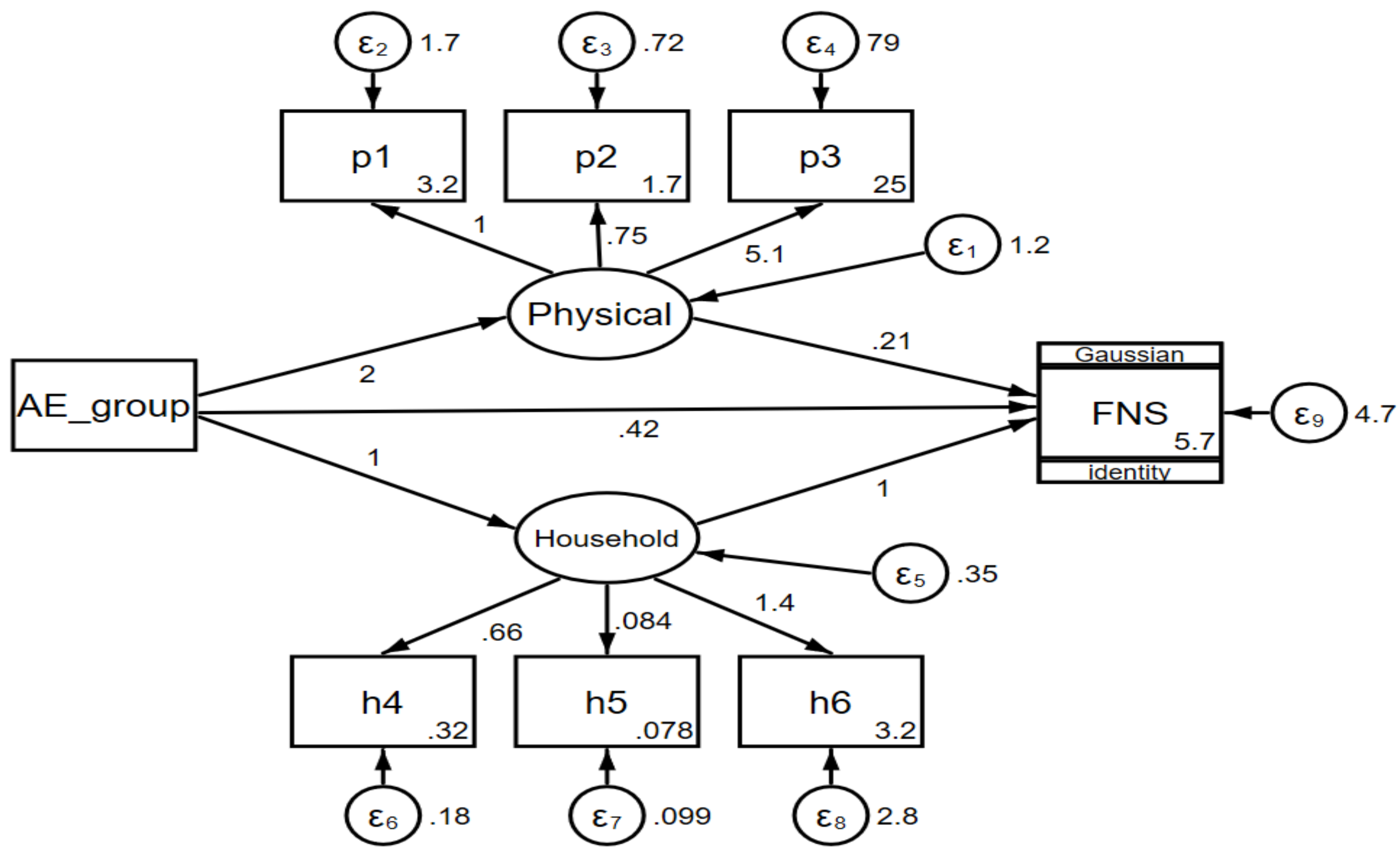

Figure2: Path analysis result

4.0 Discussion and conclusion

In this study, we empirically investigated the possible pathways through which agroecology can affect food and nutrition security by fitting data from rural Nigeria to a structural equation model framework. Initially, we conducted a bi-variant regression analysis to know if there is any relationship between agroecology and FSN before proceeding to the investigation of the pathways. The result of the bi-variant regression analysis suggested that there exists a relationship between being in an agroecology group and being food and nutrition secured. The result suggests that the action of the agroecology group in the study area has been effective in improving the nutrition and food security status of their members. This supports claims made by other studies in other parts of Sub-Saharan Africa which presents agroecology as a movement aimed at improving food security and nutrition among smallholder farmers (Bezner Kerr, Hickey, Lupafya, & Dakishoni, 2019; Kangmennaang et al., 2017; Kassie, Fisher, Muricho, & Diiro, 2020; Mdee, Wostry, Coulson, & Maro, 2019). Out of the three pathways proposed in literature, our quantitative analysis showed that agroecology affects food security and nutrition mainly through two pathways which are the physical reproduction pathways and the household reproduction pathways. The significance of the covariance between these two pathways suggests that the physical reproduction activities in the field play significant role in the household activities that go on at the home. This supports the assertion made by Peoples' Food Sovereignty Statement (2007) that the goal of healthy and culturally appropriate food among households is enhanced through the agency in producing in an ecologically sound and sustainable manner.

These two different pathways are characterized by farmers engaging in practices that will help sustain their production base which includes the household (Paltasingh & Lingam, 2014) and the soil (Altieri et al., 2012). The statistically significant result of the physical reproduction pathways in our study indicates that farmers who spend time nurturing the soil by the application sustainable soil management strategies are better off in terms of the food and nutrition status compared to farmers who do not properly manage their soil. Pretty et al. (2003) examined the extent to environmentally sensitive practices such as zero tillage and inorganic composting can improve food production by surveying over 8.98 million farmers in 52 developing countries. The authors reported that the adoption of agroecological practices in the field significantly improves food availability for farmers. In terms of access to food, Nandi, Nedumaran, & Ravula (2021) reported that farmers who strategize their food security by orientating towards their own food production achieve a better level of food security compared to those who are oriented towards the market. Results of our analysis further showed that own food production is a significant pathway through which agroecology can help improve food and nutrition status of farmers. This invariably shows the inefficiency of markets in helping smallholder farers in realizing their food needs. This suggests the need for support of national policies and better markets that will engender local markets and exchange systems that will benefit smallholders and deemphasize on cash crop production as the panacea for food insecurity challenges.

Conclusively, this study was based on smallholder farmers and does not tell much about the effect of agroecology on the food security of medium and large-scale farmers. Recent studies have been suggesting the possibility of medium-scale agriculture in addressing the present and long-term food security challenges (Asmelash, 2002; Omotilewa et al., 2021). This calls for a need for future studies investigating the values and goals of medium-scale farmers and their impact on their food and nutrition security.

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