Discover Food

Research

Externalities and sustainable agri-food system

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Abstract
The study investigated the influence of externalities on sustainable agri-food systems. The purpose was to find out the extent to which the inclusion of the cost of externalities in the price of food will translate to a more sustainable agricultural food system. The study used the cross-sectional survey design consisting of 216 randomly selected farmers of agri-food, in south-south Nigeria. A structured questionnaire served as the instrument of data collection. Convergent and divergent validity tests served to test for validity of the questionnaire while composite reliability tests served the purpose of testing for reliability. The study employed path diagram analysis using the structural equation modelling technique to test for the significance of data. The results indicate that the various costs of externalities (environmental, social, health and economic) have statistically significant relationships with agri-food sustainability. The study recommends including the cost of externalities in food pricing facilitating the drive towards a sustainable food system. The study makes a significant contribution to empirical and theoretical literature.

Keywords Agri-food sustainability · Cost of environmental externalities · Cost of social externalities · Cost of health externalities · Cost of economic externalities

1 Introduction

The advent of technology and its application to agriculture and agri-food systems has stimulated dramatic changes in agriculture in the last ten to twenty decades. This has led to soaring food and fibre productivity due to the application of "new technologies, mechanization, increased chemical use, specialization, and government policies" [1] geared towards the maximisation of agricultural outputs and reduction of food prices. A major fallout of these changes is that fewer farmers produce more food and fibre at lower prices.

The various dimensions of farming, including product diversity, price efficiency, technical progress, technological progress, and social justice [2, 3], emerged over the years, especially efficiency, technical progress and pricing which do not reflect the true cost of food, and which have contributed to various externalities with their consequences on the environment.

While implementing modern farming practices to enhance agri-food production to feed the world, it is important to take due cognisance of the environment and put plans in place to protect it and the biological variability of living things, owing to its conspicuous increasing exposure to risks. At present, the rising consciousness of the public about the consequences of the industrialised food system, has stimulated increased assistance to the creative market for economically, socially, and ecologically sustainable food production systems and has led to improvement in the demands

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for changes in agricultural policies and regulations [4]. There are also agitations to revisit the costs of food prices, which are currently not the true cost of food [5, 6].

In food production, there is a need to prioritise "the restoration and protection of ecosystems and sustainable food systems, which requires a forward-looking rational management strategy and fundamental changes in patterns and practices of economic development, product, and production" [7]. Furthermore, there is a need to redesign so that a neutral and positive environmental impact in conjunction with healthy nutrition and food safety will become evident. Policymakers should also prioritise and make investments that will translate to a healthy environment by using low environmental impact strategies. This study investigates and analyses sustainable food systems, particularly agri-food systems to ascertain the major factors responsible for a sustainable food system. In this regard, the study specifically focuses on the externalities as they affect the food system to determine the extent to which the inclusion of the externalities in the pricing of agri-foods can contribute to the enhancement of agri-food system. To this end, we analysed the established strategies for developing sustainable agri-food systems, the consequences of externalities on the agri-food system and the impact that the inclusion of externalities in the pricing of agri-food systems will have on its sustainability.

The need to enhance food production to provide food security led to the use of technology in food production. The developments associated with improved food production had many positive effects on agricultural productivity and reduced many risks in farming. However, it has also introduced significant costs. Some of the major Costs relate to the depletion of the topsoil and the contamination of the underground water. The others relate to the pollution of air, the emission of greenhouse Gas, the intrusion into space and subsequently, the diminishing of family farms. In addition, there is the abandonment of the conditions of farm labourers, especially their living and working conditions; the surfacing of new threats to human health and safety of food coupled with the agricultural industries, and the disintegration of rural communities [1]. There are reservations about the emergence of these high costs and it is the focus of the movement for sustainable agriculture (MSA). The movement is receiving unprecedented support and growing acceptance by stakeholders in food production systems. Sustainable agriculture needs to integrate three major goals, among others. The major goals are environmental health, economic profitability, and social equity [1]. The emphasis on environmental health is because the environment must be clean and healthy to support the operations of food production. Secondly, it must be economically profitable to encourage the continued participation of the current actors and attract new participants. Lastly, it must be associated with social equity to ensure that it has the backing of society.

The concerns for global warming and environmental protection have stimulated empirical studies on sustainable agriculture. These studies are gaining further attention because of the popularisation of SDGs 2 and 3 of zero hunger as well as, good health and well-being respectively. Contemporary times require agriculture that is resistant to climate change globally. A thorough understanding of the negative effects of climate change on agriculture, especially on the growth and development of plants coupled with the formulation of appropriate strategies capable of counteracting the effects of climate change on agriculture is of great importance for sustainable agriculture capable of withstanding climate change [8].

Among other things, a sustainable food system should have efficient energy, the capacity to contribute to health and safety, the capacity to raise awareness of food and agriculture, the ability to generate an economic source for farmers, as well as, the ability to use creative water conservation as its major characteristics [4].

Singh and Singh [8] advocates the need for traditional agriculture to serve as a climate-smart agricultural approach to sustain food production. This flows from its capacity to adapt and mitigate climate change through the agroecological features. Shah et al. [9] suggested that rhizobacteria should be used to promote plant growth in agriculture to enhance climate change resistance. Gabriel et al. [10] observe that farmers' greatest needs as regards the adaptation of climate-smart adaptation, mitigation and profitability are critical to the reduction of in-season crop loss, increased water use efficiency and increased productivity.

Queiroz and Norström [11] observe that investment in resilient agri-food systems in the most unsafe and risky regions can make a significant contribution to the enhancement of sustainable food systems. Heider et al. [12] found that of fourteen (14) sustainable practices, the farmers in the Mediterranean region adopt nine, on average, while adaptation to climate change practices, is consciously adopted by the majority of them. Carlisle et al. [13] observed that the growth and sustenance of an ecologically skilled workforce could contribute significantly towards the transition to sustainable agriculture. Finger [14] shows that digital innovation can enhance sustainable and resilient agricultural systems. While the need to engage in sustainable agricultural practices is not contestable, some empirical studies indicate that limited financial capacity to fund sustainability practices is a major constraint to sustainable agriculture [4, 11, 13–16]. This is a fallout of the pricing of agricultural products, especially the challenges of true cost pricing of the food system. Among other constraints, the major constraint to the true cost pricing of food is the non-inclusion of externalities in the current food price system despite the generation of considerable costs in terms of environmental, health, and social consequences by the global food system [17–21]. This exacerbates the negative consequences of the pricing of the food system through environmental, health and social externalities.

There is empirical evidence that about eight hundred and thirty million (830 million) people are malnourished while over ten million people die yearly due to unhealthy eating patterns [10, 19]. In addition, there is significant degradation of the environment and land coupled with the degradation of the soil and biodiversity. Unhealthy eating patterns, driven partially by inappropriate food pricing, can negatively influence society. This includes the exploitation of vulnerable populations, particularly children, who often work under hazardous conditions within the food production system [20, 21]. The same applies to inappropriate food pricing which is a major cause of unhealthy eating patterns. Such malfunctioning associated with the agri-food system precipitates externalities, thus, making the quantification of the costs of the externalities of the food system important [18, 22]. The United Nations Food System Summit (UNFSS) has highlighted the need to realise the value of food through a better assessment and mitigation of the economic, social, and environmental impact and externalities. A series of articles and events preceding the Summit, including the Scientific Group's June 2021 article on the True Cost and True Price of Food, have reinforced this [12, 18].

The negative trade-off between the direct payment for food and the expensive unintended consequences of the modern agri-food system (externalities) which do not reflect in the prices paid by consumers or received by producers underscores the need to estimate the true cost of food [18] due to conspicuous gaps between the current market incentives and the true cost of food. To this end, this study examines the extent to which true pricing of the food system can facilitate the attainment of a sustainable food system. Specifically, the study sought to find out the extent to which the inclusion of the cost of externalities (environmental, social, health and economic) in food pricing will contribute to the achievement of a sustainable food system.

Given the above, the study formulated and tested the following null hypotheses.

1. There is no significant relationship between the cost of environmental externalities and agri-food sustainability
2. The cost of social externalities does not have any significant relationship with agri-food sustainability
3. The cost of health externalities does not have any significant relationship with agri-food sustainability
4. The cost of economic externalities does not have any significant relationship with agri-food sustainability

2 Materials and methods

2.1 Research design

The study used a cross-sectional survey design of 233 farmers of agri-food, consisting of mainly grains, tubers and vegetables from Ekpoma, Auchi, Sapele, Abraka and Ughelli in South-South Nigeria. The study elicited information about the respondent's perception of the research problem and generalised it to the population. The study used the Taro Yamane formula to determine the sample size of 233 farmers from the 560 registered farmers in corporative societies in South-South Nigeria using a margin of error of 5%. The study used simple random sampling (lottery method) to select the desired number of respondents from farmers. Thus, the sampling technique is random (stratified). The study invited 233 participants but 216 of the invited participants responded. The study stratified the farmers based on their crop category (type of crop farmed) while the lottery method was used to randomise the selection. The data collection was between February and April 2024. The study used a structured questionnaire of the five-point Likert scale type to collect the research data in a face-to-face method from the farmers' cooperative offices.

2.2 Validity and reliability of research instrument

The study used expert opinion, convergent validity (CV) and discriminant validity (DV) to validate the instrument. The average variance extracted (AVE) for the cost of environmental externalities, as well as, social externalities, health externalities and economic externalities were all greater than 0.5, thus establishing the validity of the research instrument against a benchmark of 0.5 consistent with [22] (see Table 1). The study compared the average factor loadings with the correlations to confirm the discriminant validity (See Table 2). The average factor loadings replaced the unit elements in the leading diagonal of the correlation matrix. The study compared all correlation coefficients in each column with the

Table 1 Convergent validity AVE $=\left(\frac{\sum \lambda_i}{n}\right)^2$

1 .cee	$\left(\frac{2.2169}{3}\right)^2$	$=0.73896^2$	$=0.5461$
2 .cse	$\left(\frac{2.243}{3}\right)^2$	$=0.7473^2$	$=0.5585$
3 .che	$\left(\frac{2.354}{3}\right)^2$	$=0.7857^2$	$=0.6157$
4 .cecoe	$\left(\frac{2.483}{3}\right)^2$	$=0.8277^2$	$=0.685$
5 .sus	$\left(\frac{2.892}{4}\right)^2$	$=0.723^2$	$=0.523$

Construct Validity $=0.8418-0.272=0.615$

Table 2 Discriminant validity

	cee	cse	che	cecoe	sus
.cee	**0.739**				
.cse	0.551	**0.747**			
.che	0.105	0.277	**0.786**		
.cecoe	0.523	0.260	0.094	**0.828**	
sus	0.319	0.491	0.265	0.018	**0.723**

Table 3 Composite reliability

.cee	$\frac{2.2169^2}{3.2169^2+2.767}$	= 0.6400
.cse	$\frac{2.242^2}{2.242^2+3.21}$	= 0.6103
.che	$\frac{2.354^2}{2.354^2+1.148}$	= 0.80433
.cecoe	$\frac{2.483^2}{2.483^2+1.348}$	= 0.8206
.sus	$\frac{2.892^2}{2.892^2+2.281}$	= 0.7857

corresponding diagonal average factor loadings. Since no correlation coefficient is greater than the corresponding average factor loading, discriminant validity is established (See Table 2). The study used the Composite reliability technique to test the reliability of the instrument using the formula:

$$R = \frac{\left(\sum \lambda_i\right)^2}{\left(\sum \lambda_i\right)^2 + \sum e_i}$$

where: R = reliability of the instrument, .λ_i = factor loadings (standardised factor loadings, .$e_i = 1 - \lambda_i{}^2$ = residuals, i.e. the difference between the squared factor loadings and 1.

The coefficients computed for the variables (environmental externalities, social externalities, health externalities and economic externalities) were all greater than 0.5, thus indicating that the instrument is reliable and consistent with the findings of [23]. The implication is that the items in the instrument are internally consistent (See Table 3).

2.3 Multicollinearity test

To address the problem of common method variance arising from the use of a self-reporting instrument, the study conducted a Multicollinearity test. The results show that the highest VIF is 1.917, corresponding to the cost of health externalities. Since this value is less than 5–10, we conclude that the value is within the tolerance limit consistent with [24]. The least tolerance limit is 0.538, which corresponds to the cost of environmental externalities. Since this value is not less than 0.1–0.2 [24], the

Table 4 Multicolinearity test

Variable	Tolerance	VIF
Constant		
Cost of environmental Externalities	0.538	1.857
Cost of Social Externalities	0.646	1.548
Cost of health Externalities	0.917	1.917
Cost of economic Externalities	0.723	1.384

Table 5 Descriptive statistics

Variable	Mean	Standard deviation	N
.cee	3.8414	0.6976	216
.cse	3.6053	0.6618	216
.che	3.6053	0.6087	216
.cecoe	3.3287	0.6129	216
.sfs	3.8241	0.6291	216

implication is that it is within tolerance. In addition, the average variance inflation factor (VIF) indicates that the coefficient is within the tolerance limit. Consequently, there is no significant multicollinearity. Thus, the data are not subject to common method variance (See Table 4).

2.4 Model specification

The study's model is as follows:

.sfs f (coee, cose, cohe and coecoe).

Specifically,

$$.sfs = \beta\_0 + \beta\_1coee + \beta\_2\ cose + \beta\_3\ cohe + \beta\_4coecoe + .e \tag{i}$$

Where .sfs = sustainable food system, .coee = cost of environmental externalities, .cose = cost of social externalities, .cohe = cost of health externalities, Coecoe = cost of economic externalities, .e = stochastic error term, β_0 = Fraction of the changes in the sustainable food system that the variations in the explanatory variables (coee, cose, cohe and coecoe) do not account for. β_i (i = 1, 2, 3 and 4) = Coefficients of the explanatory variables (cost of environmental externalities, cost of social externalities, cost of health externalities and cost of economic externalities).

2.5 Data analysis technique

The study employed descriptive and inferential statistics to analyse the data. The descriptive statistics are tables, mean responses, the standard deviation and the standard error mean of the respondents' responses. The path diagram analysis of the structural equation model (sem) is the major inferential test. The study chose the sem technique because of the inclusion

Table 6 Structural equation model of food externalities and agric. sustainability

	OIM					
	Coef	Std. Err	z	P > |z|	[95% Conf. Interval]	
Structural						
sus < -						
cee	.1692601	.0702653	2.41	0.016	.0315425	.3069776
cse	.3761288	.0676083	5.56	0.000	.243619	.5086386
che	.1586955	.0617066	2.57	0.010	.0377527	.2796382
cecoe	− .2027503	.0690252	− 2.94	0.003	− .3380372	− .0674634

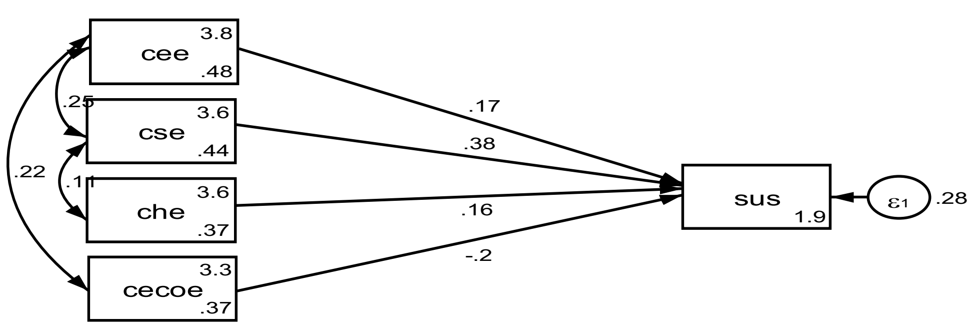

Fig. 1 Cost of externalities and agricultural sustainability

Table 7 Goodness of fit tests

Equation-level goodness of fit						
	Variance					
depvars	Fitted	Predicted	Residual	R-squared	mc	mc2
Observed						
sus	.392661	.1145247	.278137	.291663	.540058	.291663
Overall				.2916629	RMSE: 0.5003	
Wald tests for equations						
	chi2	df	p			
Observed						
sus	88.94	4	0.0000			
Fit statistics						
Fit statistic	Value	Description				
Likelihood ratio						
chi2_ms(0)	0.000	model vs. saturated				
p > chi2						
chi2_bs(4)	74.484	baseline vs. saturated				
p > chi2	0.000					

of a mediating variable in the research problem since the path diagrams of technique sem are very effective in mediation analysis.

3 Results

The results of the responses of the study's participants on the research problem show that the means and standard deviations of the cost of environmental externalities (coee), cost of social externalities (cose), cost of health externalities (cohe), cost of economic externalities (coecoe) and sustainable food system (sfs) were 3.84 (0.698), 3.6053(0.6618), 3.6053 (0.6087), 3.3287 (0.6129) and 3.8241 (0.6291) respectively. The implication is that all the means surpass the cut-off mark of 3.0. The standard deviations are within the interval of 0.6129 and 0.6976 respectively. The cost of economic externalities (cecoe) has the lowest standard deviation while the cost of environmental externalities (cee) has the highest standard (See Table 5).

The structural equations model results for the cost of externalities and sustainability of agricultural food system show that the constant and coefficients of the cost of environmental externalities (cee), cost of social externalities (cse), cost of health externalities (che), and cost of economic externalities (cecoe) were 0.1693, 0.3761, 0.1587, and − 0.2028. Thus, the specific research model is:

$$.asus = 0.1693\,cee + 0.3761\,cse + 0.158\,che - 0.2028\,ceco \tag{i}$$

The model which equation (i) depicts implies that a unit change in the cost of environmental externalities in food pricing will cause a 16.93% change in agri-food sustainability. In addition, a unit change in the cost of social externalities will lead to a 37.61% change in agri-food sustainability. Besides, a unit change in the cost of health externalities will stimulate a 15.8% variation in agri-food sustainability. Finally, a unit variation in the cost of economic externalities will result in a 20.28% change in agri-food sustainability. The results of the tests for the significance of these coefficients indicate that the computed Z and the asymptotic significant probabilities associated with the Z statistic for the cost of environmental externalities is 2.41 (0.016). The computed z and p values for the other costs of externalities are 5.56 ($P < 0.001$), 2.57 ($P < 0.010$) and – 2.94 (0.003) for social externalities, health externalities and economic externalities respectively (See Table 6 and Fig. 1). To this end, all the explanatory variables (cee, cse, che and cecoe) have statistically significant relationships with agri-food sustainability at the five per cent, one per cent, five per cent and five per cent levels respectively. Apart from the relationship between the cost of economic externalities and agri-food sustainability, all the other relationships were positive. The implication is that changes in the inclusion of the costs of externalities (environmental, social and health) will influence agri-food sustainability positively and the positive influences will be statistically significant. The changes in economic externalities will negatively influence agri-food sustainability and the negative influences will be statistically significant (See Table 6).

The study tested for goodness of fit using four techniques. The four techniques are the equation level goodness of fit test, the Root Mean Square Error (RMSE), the Wald test and the Fit Statistic. The results of the equation-level goodness-of-fit test indicate that 0.3927 and 0.1145 are the fitted and predicted variances of agri-food sustainability, thus yielding a residual value of 0.2781. This resulted in an overall goodness of fit of 0.2917. This means that the changes in the explanatory variables (environmental, social, health and economic externalities) explain twenty-nine point seventeen per cent (29.17%) of the variation in agri-food sustainability (See Table 7). The results of the RMSE indicate a computed value of 0.5003 (See Table 7). This value is indicative of a good fit. The Wald test for the significance of equations had 89.94 ($p < 0.001$) as the computed Chi-square and the associated significant p-value, thus, indicating that the coefficients of the explanatory variables are significantly different from zero and thereby, statistically significant (See Table 7). The fit statistics show that the computed Chi-square for the model versus saturate is 0.000. This means that the model is not different from the saturated. Specifically, the model is the same as the saturated. In addition, a comparison of the baseline with the saturated shows that the computed Chi-square statistic and the associated significant probability are 74.484 ($p < 0.00$). The implication is that the baseline model differs significantly from the saturated based on the discrepancies in the computed statistics (See Table 7). Consequently, the results of the tests for goodness of fit suggest that the sem model used is a good fit for the research data.

3.1 Discussion of findings

The first specific objective of the study sought to investigate the degree to which the cost of environmental externalities influences agri-food sustainability. This study realised this objective in testing the first null hypothesis "there is no significant relationship between the cost of environmental externalities and agri-food sustainability". Based on the significance of the results of the sem, the study rejected the first null hypothesis thus, indicating that the cost of environmental externalities has a positive relationship with agri-food sustainability and the positive relationship is statistically significant at the five per cent level. This tends to suggest that the cost of environmental externalities significantly influences agri-food sustainability. The results support the studies conducted by [18–21]. The second specific objective was to investigate the degree to which the cost of social externalities influences agri-food sustainability. This study realised this objective by testing the second null hypothesis "There is no significant relationship between the cost of social externalities and agri-food sustainability." Based on the significance of the results of the sem, the study rejected the second null hypothesis, thus suggesting that the cost of social externalities has a positive relationship with agri-food sustainability, and this positive relationship turned out to be statistically significant at the one per cent level. The results provide support for the studies of [17], [18–20], and [21].

The third specific objective of the study sought to investigate the degree to which the cost of health externalities influences agri-food sustainability. This study realised this objective by testing the third null hypothesis "There is no

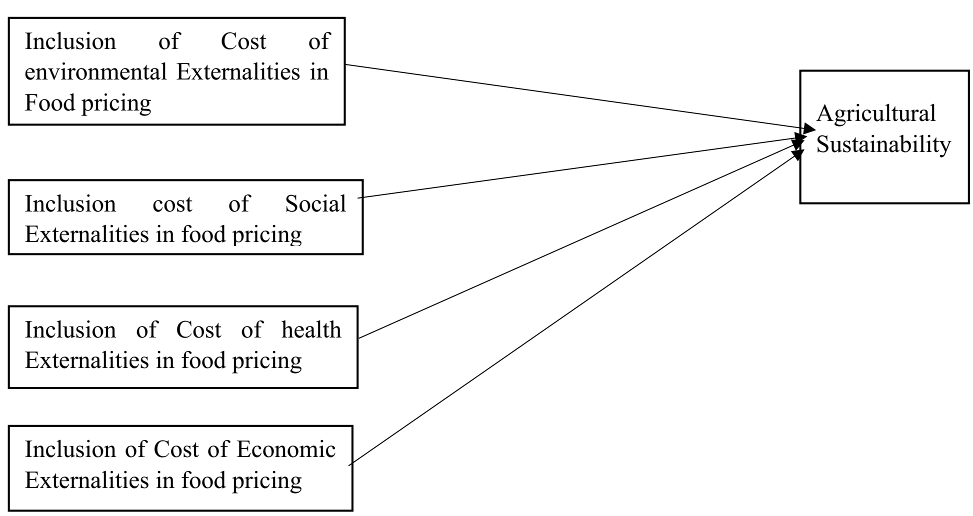

Fig. 2 Proposed model of the cost of externalities and agricultural sustainability

significant relationship between the cost of health externalities and agri-food sustainability." Based on the statistical significance of the sem results, the study rejects the null hypothesis, thus indicating that the cost of health externalities has a positive relationship with agri-food sustainability and the positive relationship is statistically significant at the five per cent level. The results provide support for the studies of [18–20], and [21]. The fourth specific objective of the study sought to investigate the degree to which the cost of economic externalities influences agri-food sustainability. This study realised this objective by testing the fourth null hypothesis "There is no significant relationship between the cost of economic externalities and agri-food sustainability." Based on the results of the sem, the study rejects the null hypothesis thus, indicating that the cost of economic externalities has a negative relationship with agri-food sustainability and the negative relationship is statistically significant at the five per cent level. It is pertinent to note that only the cost of economic externalities had a negative relationship with agri-food stainability, whereas, the costs of environmental, social and health externalities all have statistically significant positive relationships with the sustainability of agri-food food system. This may be because the agricultural products are currently taking due cognisance of the economic externalities while neglecting the environmental, social and health externalities. The positive relationships between the costs of the other externalities (environmental, social and health) and sustainability indicate that an increase in the inclusion of the cost of these externalities in food pricing would increase the sustainability of the agri-food system and vice versa. The study's finding of the current non-inclusion or neglect of social, environmental and health externalities by the food system provides support for the studies of [18–20], and [21]. In the final analysis, the non-inclusion of the costs of social, environmental and health externalities in the food prices by the current food system as observed in this study's findings is a jeopardy to sustainability. To ensure the food system's sustainability, the costs of social, environmental and health externalities associated with the current agri-food system must be included in food pricing. Inclusion of the costs of all categories of externalities, especially the cost of the social, environmental and health externalities in the prices of the current agri-food system will ensure the appropriateness of the pricing of agri-food products. The appropriate pricing of agri-food products will make investment in agriculture attractive and thus lead to increased participation in food production. This will ultimately facilitate the attainment of agri-food sustainability and food security. Incorporating the cost of externalities into the food price system will surely increase the monetary value of food but lead to a reduction in the cost of externalities such as environmental pollution, unhealthy foods and the social consequences associated with the current food system. In the final analysis, the consumers will have a positive trade-off due to the reduced consequences of externalities.

3.2 Proposed model

Based on the findings, the study proposes a model of the cost of externalities (environmental, social, health and economic) and agri-food sustainability (see Fig. 2). The proposed model shows that the cost of environmental externalities, as well as, the costs of social externalities, health externalities and economic externalities all have significant relationships with the sustainability of the agri-food system. To this end, incorporating the costs of the various externalities will enable the true pricing of the global food system and thus help avoid the consequences associated with the different externalities. By catering for the cost of externalities of the food system, the food, the society and the environment will become safer. This will empower the farmers to engage in sustainable agricultural practices. This is consistent with [4, 11, 15] and [13]

4 Policy implications

The implications of the study for the local market, institutions and policy development to improve the sustainability of the agri-food systems is that agri-food stakeholders should be conscious of the need to include the costs of externalities in the pricing of agri-foods so that it can reflect the true cost of agri-foods for sustainability. However, local market operators and institutions require the support of policymakers to succeed, owing to the huge cost requirement to implement a true cost pricing of agri-foods. This implies that the government must be willing to subsidise the true cost pricing of food to forestall the increase in investment in healthcare because of the consequences of unpriced externalities that may constrain healthy food consumption. In any case, there is the need for concerted efforts at the regional and global levels to tackle the cost of externalities and prevent the importation of cheaper agri-foods with consequences of externalities when there are attempts at the local level to address the negative effects of these externalities.

5 Conclusion

This study concludes that the cost of environmental externalities, as well as, the costs of social externalities, and health externalities have significant positive relationships with the sustainability of the agri-food system. The cost of economic externalities has a negative relationship with the sustainability of the agri-food system.

This study has contributed to knowledge in the agricultural and food sciences and management science research. First, it has verified the relevance of the impact of the cost of externalities on the food system. While most studies on the true cost of food and sustainable agriculture are review articles, this study has provided an empirical basis to support the studies. Secondly, it has provided an empirical confirmation of the importance of the cost of externalities to agri-food sustainability. Thus, the positive relationship between the cost of externalities and agri-food sustainability suggests that catering for the cost of externalities through true cost pricing will reduce the negative influences of externalities and thus enhance sustainability. This marks a point of departure from most previous studies that did not provide any empirical basis for their conclusions on the relationship between the cost of externalities and food sustainability. It is also pertinent to note that this study finds a negative relationship between economic sustainability and food production. This result does not only indicate that most food producers are already catering for economic externalities but that they are exploiting the consumers through the pricing of the food system by not channelling part of the proceeds of their sales to cater for environmental and social needs as well as through the production and sale of unhealthy foods. Lastly, the proposed framework of the study for the cost of externalities and sustainable agricultural systems is insightful and useful.

The study has some constraints, which suggest the need for further studies. The first major constraint concerns its restriction to Nigerian respondents only. Including respondents, especially farmers, outside Nigeria would have introduced an international perspective to respondents' perception of the various dimensions of externalities; this would have paved the way for insightful comparisons and possible generalisations. Nevertheless, the availability of supporting literature on the subject matter from other parts of the world tends to mitigate this constraint. This notwithstanding, this study suggests the need for future studies to consider international studies of the research problem.

5.1 Recommendations

Food is vital to human existence as no human and other living being can survive without food. This makes food production critical to the existence of humans. In other words, Humans cannot live without food. This is why food security is necessary for humanity. However, destroying the ecosystem to provide food for humankind is inimical to human survival because it will cause the cessation of human existence. To this end, the need to balance the quest for food and the sustenance of the human environment, social life and human safety becomes inevitable. Because of these, the study suggests the following recommendations. Critical stakeholders should strategize on how to sensitise the key actors in the food system on incorporating the cost of externalities in the food price system to minimise the degree of externalities in the food system. For this to succeed, the need for various governments to subsidise food prices becomes important as the inclusion of the costs of externalities in the food prices may cause the prices to be out of reach for the average food consumers. It is also important for consumers to be sensitised on the need for a true-cost food system and its benefits to humankind. This will help them understand the changes in the food prices when the true cost pricing takes effect. It is important to inform everyone that without including the costs of externalities in the true cost of food, the threats posed by the externalities in food production will destroy the human environment and alter the course of nature, which may lead to the cessation of humanity.

6 Appendix (Questionnaire)

6.1 Instruction

Please tick in ( ) appropriate column or fill in where necessary as the case may be.

6.2 SECTION A

1. Sex: (a) Male ( ) (b) Female ( )
2. Educational status: School Certificate [ ] OND/NCE [ ] HND/B. SC [ ] (e) M. SC or Higher Degrees [ ]

6.3 SECTION B: Research Problem

Indicate the extent to which you agree with each of the following items.

1	2	3	4	5
Strongly Disagree	Disagree	No View	Agree	Strongly Agree

	Indicate the extent to which you agree that the prices of the food system currently shoulds include the following costs	Score
A	*Cost of Environmental Externalities*	
Q1	Cost of Air pollution	
Q2	Cost of water pollution	
Q3	Cost of Soil pollution	
Q4	Cost of Soil depletion	
B	*Cost of Social Externalities*	
Q5	Cost of underpayment	
Q6	Cost of child and forced labour	
Q7	The cost of discrimination and harassment	
Q8	The cost of variable food prices	
C	*Cost of Health Externalities*	
Q9	The cost of undernutrition	
Q10	The cost of unhealthy diets	
Q11	The Cost of obesity	
Q12	The cost of antimicrobial resistance	
D	*Cost of Economic Externalities*	
Q13	The cost of food waste	
Q14	Underpayment in the agricultural sector	
Q15	Underproduction of food	
E	*Sustainability*	
	Indicate the extent to which you agree that the following factors will facilitate a sustainable food system	
Q16	Economic sustainability (profitability)	
Q17	Social sustainability (provision of benefits for the society)	
Q18	Environmental sustainability (provision of positive impact on the natural environment)	
Q19	Healthconsideration (provision of healthy diets)	

Author contributions H.E—Conceptualisation, introduction, literature review, methodology, analysis, interpretation, discussion, conclusion, references, funding, and supervision.

Data availability The study used primary data. The dataset will be made available on reasonable request.

Declarations

Ethics approval and consent to participate The author sought and got ethical approval from the Research Ethical Board of his institution (Bowen University, Iwo, Nigeria). The study complied with ethical standards. There was no number attached to the approval. The researcher sought and got the informed consent of the participants to participate in the study as the author duly informed them of the purpose and informed them that participation was voluntary using the Statement, "I am conducting a study on the drivers of the sustainable agri-food system. Your responses will be anonymous and used to analyse the research problem. Participation is voluntary" Out of the 233 sampled participants, 216 accepted and voluntarily participated in the study after the researcher assured them of anonymity and that their responses were solely for academic purposes. The remaining 17 declined.

Competing interests The authors declare no competing interests.

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