agriculture

Article

Improving Rural Livelihood through the Cultivation of Indigenous Fruits and Vegetables: Evidence from Ondo State, Nigeria

Similoluwa Felicia Olowo [1], Abiodun Olusola Omotayo [2,*], Ibraheem Oduola Lawal [3] and Adeyemi Oladapo Aremu [1,2]

1 Indigenous Knowledge Systems Centre, Faculty of Natural and Agricultural Sciences, North-West University, Mmabatho 2745, South Africa; 34340734@student.g.nwu.ac.za (S.F.O.); oladapo.aremu@nwu.ac.za (A.O.A.)
2 Food Security and Safety Niche Area, Faculty of Natural and Agricultural Sciences, North-West University, Mmabatho 2745, South Africa
3 Bio Medicinal Research Centre, Forestry Research Institute of Nigeria, Ibadan 200272, Nigeria; lawal.io@frin.gov.ng
* Correspondence: 25301284@nwu.ac.za (A.O.O.)

check for updates

Citation: Olowo, S.F.; Omotayo, A.O.; Lawal, I.O.; Aremu, A.O. Improving Rural Livelihood through the Cultivation of Indigenous Fruits and Vegetables: Evidence from Ondo State, Nigeria. *Agriculture* **2022**, *12*, 372. https://doi.org/10.3390/agriculture12030372

Academic Editor: Sanzidur Rahman

Received: 9 January 2022
Accepted: 28 February 2022
Published: 7 March 2022

Abstract: The potential value of the efficient utilization of rural lands to cultivate indigenous fruits and vegetables to improve the livelihood of farming households cannot be overemphasized. Using primary data from 400 randomly selected rural farming households in Ondo State, Nigeria, this study applied probit regression, principal component analysis (PCA), and propensity score matching (PSM) models to investigate the factors that determine the decisions of households to utilize their lands to cultivate indigenous fruits and vegetables. The impact of their cultivation on the livelihood of the participants was assessed, and the result revealed that they were profitable (NGN19,187.8/USD 42.60/Ha; Nigerian Naira = NGN, USD = United States Dollar). The farmers who cultivated indigenous fruits and vegetables (n = 277) made an additional 29.40% average total farm revenue than those (n = 123) who did not. Based on the probit regression analysis, factors such as educational attainment, access to government subsidies, and knowledge of the nutritional benefit of the indigenous fruits and vegetables influenced the decision of farmers to cultivate indigenous fruits and vegetables. The PSM model established that the cultivation of indigenous plants increased farm revenue and livelihood outcomes by NGN17,604.85 and NGN2265.00, respectively. In this context, the cultivation of indigenous fruits and vegetables in the selected rural communities is important for improving the livelihoods of households and suggests the need to rethink the present dominant policy narrative that neglects these indigenous plants. A concerted effort needs to focus on increasing their productivity and commercialization as a primary pathway to improve rural livelihood and transformation.

Keywords: economic botany; ethnobotany; food security; rural development; rural transformation; socioeconomic empowerment

1. Introduction

In developing countries, about 3.2 billion people live in rural areas, with many depending on agriculture food systems for their livelihoods [1–3]. Relative to other sectors, the agriculture and food sectors are unique in their scale of employment and reliance on small- and medium-sized enterprises [4]. Food systems are, therefore, critical for addressing poverty and equitably distributing economic opportunities [5–7]. Food shortage and the high prevalence of poverty in many developing countries indicate the need to expand food production and sustainable livelihoods among rural communities in particular, where more vulnerable populations live and poor livelihoods and food insecurity are aggravated [8,9]. This situation challenges the achievement of 'zero hunger', the United Nations Sustainable

Development Goals (UN SDG) number 2 target by 2030 [9,10]. Therefore, exploring the potential of indigenous plants as valuable sources of food and to encourage socioeconomic prosperity and improved livelihood cannot be over emphasized [11–14].

The cultivation of indigenous plants, especially fruits and vegetables, has been described as an important social and economic unit of rural households, from which a diverse and stable supply of economic products and benefits are derived [12,15]. Indigenous fruits and vegetables are capable of improving the nutritional status, health, socioeconomic status, food security, and livelihood outcomes of households. In addition, some indigenous plants and their products are sold in local and regional markets, thus improving the financial status and livelihoods of households. The sale of the cultivated indigenous fruits and vegetables and their products by rural households and small-scale farmers has been identified as a potential means of poverty alleviation [15–17].

In Nigeria, improving and expanding the agricultural food production to meet the increasing food need of the growing population is important. There is a need for an intensified effort to cultivate indigenous plants to ensure food availability and adequate reserves to accommodate the food requirements in rural communities for improved livelihood, economic development, and agricultural expansion [18]. Cultivated indigenous plants and agricultural fields provide rural families with income, nutritious food, and animal feed, which help communities to achieve self-sufficiency [15,19,20]. The rural poor remain "strugglers/hustlers" who undertake various enterprises through which they cobble together a livelihood. Researchers are aware of the insights of local people who are acknowledged within their own communities as experts on indigenous plants [21,22]. The inherent limitations (low acceptability, limited availability of inputs, land tenure problems, long maturity period) that affect many indigenous plant cultivation systems has resulted in their low production, leading to poor availability however, their cultivation remain active in the rural communities [15,23].

In most parts of Nigeria, the diverse indigenous fruits and vegetables and their cultivation and profitability are not adequately documented [14,22,23]. The cultivation of indigenous plants involves elaborate social, technological, and economic mechanisms to safeguard the plant resources. Therefore, we analyzed the profitability of cultivating indigenous plants, the factors influencing the decision of farmers to cultivate them on their lands, and their impact on the livelihoods of selected communal areas in Ondo State, Nigeria.

2. Materials and Methods

2.1. Study Area

The study was conducted in the Akure South local government area of Ondo State located in southwest Nigeria (Figure 1). Akure is the capital of Ondo State and has an estimated population of 665,524 and an area of 332 km^2 [24], with a major occupation being farming. It consists of 11 wards with approximately 320 communities, some being mainly rural. It is about 900 km southwest of Abuja and 311 km north of Lagos State. The climate of Akure is both hot and humid, usually caused by rain-bearing southwest monsoon winds from the ocean and dry northwest winds from the Sahara Desert. The rainy season is from April to October, with approximately 1524 mm of rainfall per year, while the dry season lasts from December to February, with the seasons influencing the crops that are grown or their maturation process. Akure lies about 7°25′ N of the equator and 75°19′ E of the meridian. Akure South is one of the 18 local governments of Ondo State, Nigeria (Figure 1). The state lies between latitude 5°45′ and 8°15′ N and longitude 4°45′ and 6° E.

Temperatures range between 28 to 31 °C with a mean annual relative humidity of 80% at 250 m/1135 ft above sea level [25]. The two major rivers are River Owena and River Ala. The study area is characterized by a flat or gentle steep and a humid forest zone. The major types of rocks found in Akure are granite and charmonite. The major occupation of the people is farming. The native language of the people of Akure is Yoruba. The people of Akure are very friendly and welcome other tribes; across the land are other ethnic groups including the Ibo, Hausa, and Fulani [25]. Akure is an agricultural trade center for cassava, corn (maize), bananas, rice, palm oil and kernels, okra, rubber, and coffee as well as various indigenous fruits and vegetables. Although cocoa is by far the most important local commercial crop, cotton, teak, and palm products are also cultivated for export.

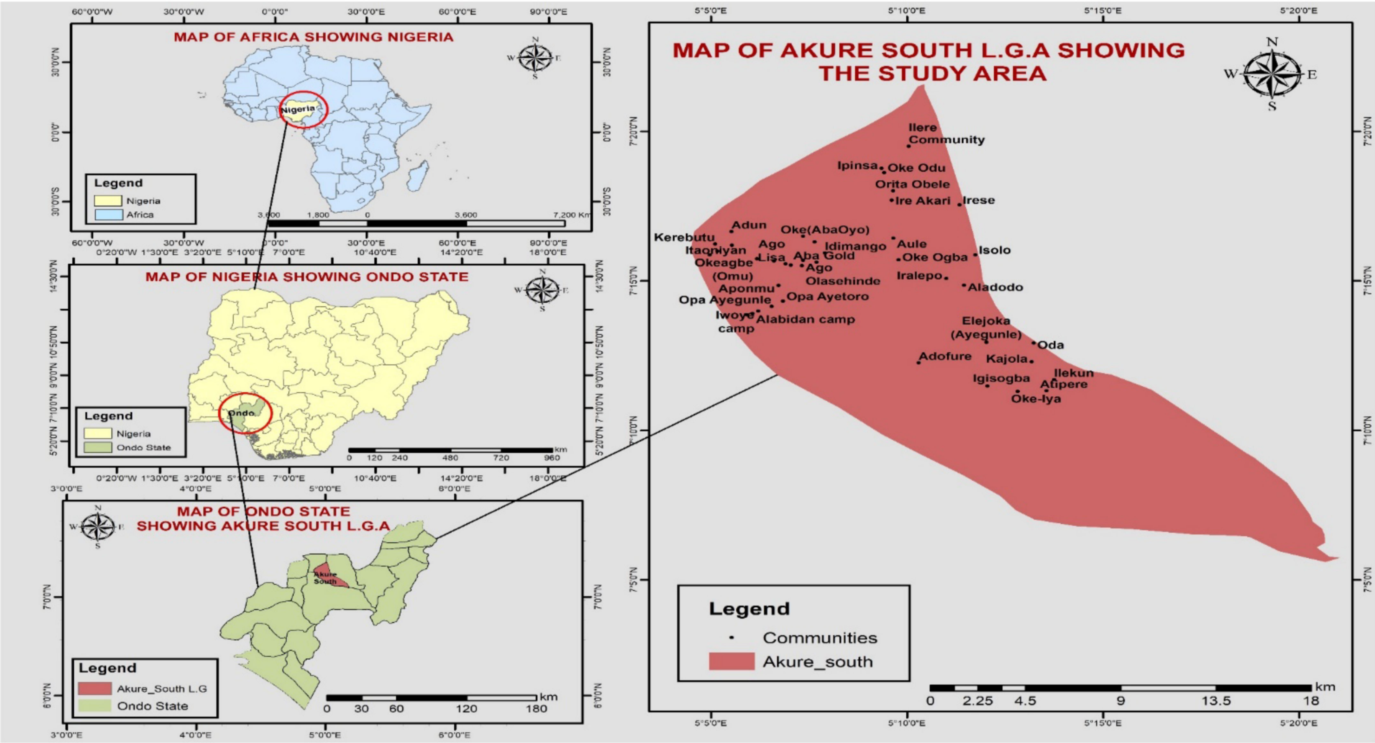

Figure 1. Geographical location of the selected communities in Akure South local government area, Ondo State, Nigeria.

2.2. Data Sampling Methods and Sample Size

The study targeted small-holder farming households with experience in the production of indigenous fruits and vegetables, with both random and purposive sampling techniques being applied. The study was conducted in a randomly selected 40 of the 320 communities in Akure South local government area. The selection of the communities was based on the availability of indigenous plants in their natural habitat. The sample size was 400 participants (10 farming households from each of the 40 communities); these farmers including those who were cultivating indigenous plants and those that are not cultivating indigenous plants. Purposive sampling was used to identify suitable households to obtain data from those who were considered to be the most knowledgeable in the field of interest or the most experienced and successful [26]. A well-structured questionnaire was developed based on the objectives of the study, with face-to-face interviews conducted in the native language (Yoruba).

2.3. Research Instrument, Validity, and Reliability

An inventory of 16 indigenous fruits and 30 vegetables recognized as important and popular in Nigeria was generated, which was used as a checklist and photo album during the study (Table 1). Prior to data collection, the voucher specimens for the selected indigenous fruits and vegetables were prepared and deposited at the herbarium of the Forestry Research Institute of Nigeria (FRIN), Ibadan, Oyo State, Nigeria.

Table 1. Scientific names and families of the selected indigenous fruits and vegetables. The names were verified using the Plant List (http://www.theplantlist.org/: Accessed on the 20 December 2021). * Vernacular Names: E = English, Y = Yoruba.

S/N	Botanical Name	Family	* Vernacular Name	Commonly Utilized Plant Parts
		16 Selected Indigenous Fruit		
1.	*Artocarpus communis* (Parkinson ex F.A.Zorn) Fosberg	Moraceae	Breadfruit (E), Berefuutu (Y)	Fruit, leaves, stem, seeds, roots
2.	*Blighia sapida* K.D.Koenig	Sapindaceae	Ackee (E), Ishin (Y)	Fruit, bark, seeds, roots
3.	*Citrus aurantifolia* L.	Rutaceae	Lime (E), Oronbo were (Y)	Fruit
4.	*Citrus aurantium* L.	Rutaceae	Orange (E), Ganinganin (Y)	Fruit, bark, and seeds
5.	*Cocos nucifera* L.	Arecaceae	Coconut (E), Agbon (Y)	Fruit and seeds
6.	*Chrysophyllum albidum* G.Don	Sapotaceae	Africa star apple (E), Agbalumo (Y)	Fruit, bark, and roots
7.	*Dialium guineense* Willd.	Leguminosae	Black velvet tamarind (E), Awin (Y)	Fruit
8.	*Elaeis guineensis* Jacq	Asteraceae	Palm oil (E), Eyin (Y)	Fruit, seeds, and oil
9.	*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill.	Irvingiaceae	Bush mango (E), Oro (Y)	Fruit, bark, seeds, and roots
10	*Irvingia wombolu* Vermoesen	Irvingiaceae	Bitter bush mango (E), Oro (Y)	Fruit and bark
11	*Parkia biglobosa* (Jacq.) G.Don	Leguminosae	Locust beans (E), Iru (Y)	Fruit and seeds
12	*Plukenetia conophora* Müll. Arg.	Euphorbiaceae	Walnut (E), Awusa (Y)	Fruit, seeds, and roots
13.	*Solanum indicum* L.	Solanaceae	African eggplant (E), Ajegun Were (Y)	Fruit
14.	*Solanum aethiopicum* Jacq.	Solanaceae	Garden egg (E), Igba (Y)	Fruit
15.	*Spondias mombin* L.	Anacardiaceae	Hog plum (E), Iyeye (Y)	Fruit
16.	*Theobroma cacao* L.	Malvaceae	Cocoa (E), Koko (Y)	Fruit, bark, seeds
		30 Selected Indigenous Vegetables		
1.	*Ageratum conyzoides* Hieron.	Asteraceae	Billy goat weed (E), Imiesu (Y)	Fruit, leaves, seeds, roots
2.	*Amaranthus hybridus* Vell	Amaranthaceae	Africa spinach (E), Tete (Y)	Leaves and stem
3.	*Amaranthus spinosus* L	Amaranthaceae	Spiny amaranthus (E), Teteelegun (Y)	Fruit, leaves, and stem
4.	*Amaranthus viridis* All	Amaranthaceae	Green amaranth (E), Teteabalaye (Y)	Leaves and stem
5.	*Andrographis paniculata* (Burm.f.) Nees	Acanthaceae	King of bitter (E), Mejemeje (Y)	Leaves, stem, and roots
6.	*Basella alba* L.	Basellaceae	Malabar spinach (E), Amunututu (Y)	Leaves and stem
7.	*Boerhavia diffusa* L.	Nyctaginaceae	Hog weed (E), Eemo/Olowojeja (Y)	Leaves and stem
8.	*Bryophyllum pinnatum* (Lam.) Oken	Crassulaceae	Miracle leave (E), Abamoda (Y)	Leaves and roots
9.	*Ceiba pentandra* (L.) Gaertn.	Malvaceae	Baobao (E), Eegungun (Y)	Leaves and seeds
10.	*Chromolaena odorata* L.	Asteraceae	Siam weed (E), Akintola (Y)	Leaves and roots

Table 1. *Cont.*

S/N	Botanical Name	Family	* Vernacular Name	Commonly Utilized Plant Parts
11.	*Cnidoscolus aconitifolius* (Mill.) I.M.Johnst.	Euphorbiaceae	Chaya (E), Iyanapaja (Y)	Leaves and stem
12.	*Crassocephalum rubens* (Juss. ex Jacq.) S.Moore	Asteraceae	Coriander (E), Ebolo (Y)	Leaves, stem, and seeds
13.	*Celosia argentea* L.	Amaranthaceae	Lagos spinach (E), Shokoyokoto (Y)	Leaves and stem
14.	*Clerodendrum volubile* P.Beauv.	Lamiaceae	White butterfly (E), Dagba (ewe ata) (Y)	Leaves and roots
15.	*Corchorus olitorius* f. grandifolius De Wild.	Malvaceae	Jute leaves (E), Ewedu (Y)	Leaves and roots
16.	*Eclipta prostrata* Lour.	Asteraceae	False daisy (E), Abikole (Y)	Leaves and stem
17.	*Gossypium barbadense* L.	Malvaceae	Cotton seed (E), Owu (Y)	Fruit and seeds
18.	*Hibiscus asper* Hook. f.	Malvaceae	Hibiscus (E), Isapa (Y)	Leaves, seeds, and flowers
19.	*Launaea taraxacifolia* (Willd.) Amin ex C. Jeffrey	Asteraceae	Wild lettuce (E), Yanrin (Y)	Leaves and stem
20.	*Manihot utilissima* Pohl	Euphorbiaceae	Cassava leaves (E), Ege (Y)	Leaves
21.	*Mucuna pruriens* (L.) DC.	Leguminosae	Mucuna leaves (E), Esisi/Iwerepe (Y)	Leaves and roots
22.	*Ocimum gratissimum* L.	Lamiaceae	Scent leaves (E), Efirin (Y)	Leaves, seeds, and roots
23.	*Sida acuta* Burm. F.	Malvaceae	Wire weed (E), Iseketu (Y)	Leaves, stem, and roots
24.	*Solanum erianthum* D. Don	Solanaceae	Big eggplant (E), EwuroIjebu (Y)	Leaves, stem, and roots
25.	*Solanum macrocarpon* Pav. ex Dunal	Solanaceae	Africa eggplant (E), Igbagba (Y)	Leaves, stem, bark, and roots
26.	*Solanum nigrum* Acerbi ex Dunal	Solanaceae	Black nightshade (E), Efo odu (Y)	Leaves, stem, and whole plant
27.	*Senecio biafrae* Oliv. and Hiern	Asteraceae	Bologi (E), Woorowo (Y)	Leaves and stem
28.	*Talinum triangulare* (Jacq.) Willd.	Talinaceae	Waterleaf (E), Gbure (Y)	Leaves and stem
29.	*Vernonia adoensis* var. Adoensis	Asteraceae	Bitter leaf (E), Ewuro odo (Y)	Leaves, stem, and whole plant
30.	*Vernonia amygdalina* Del.	Asteraceae	Bitter leaf (E), Ewuro (Y)	Leaves and stem

A well-structured questionnaire was administered along with a photo album of the selected indigenous plants for ease of identification among the 400 selected participants. The questionnaire was divided into three sections: A collected demographic characteristics; B documented their indigenous knowledge and practices on the indigenous fruits and vegetables; C established how the indigenous fruits and vegetables were produced and how they enhanced their livelihood (human, natural, social, financial, and physical capital). The questions related to data about the local indigenous plant names, uses, plant parts commonly eaten, production, harvesting, sales, income generated, and livelihood benefits.

2.4. Econometric Model Specification

Descriptive, inferential statistics and gross margin analysis were used in data analysis with the aid of STATA and SPSS software. Descriptive instruments, such as tables, percentages, graphs, and frequency distribution were used to explain the socioeconomic characteristics of the participants, while probit regression and propensity score matching analysis were employed for testing the hypothesis. The gross margin analysis was carried out to measure the profitability of indigenous plants' production. According to Omotayo and Oladejo [27], the gross margin was measured as Total Revenue (TR) less Total Variable Cost (TVC). The net return (Profit) was calculated by subtracting the Fixed Cost (FC) from the Gross Margin (GM). Mathematically: TC = TFC + TVC

$$\mathrm{GM} = \mathrm{TR} - \mathrm{TVC} \tag{1}$$

$$\mathrm{NR/PROFIT} = \mathrm{GM} - \mathrm{TFC} \tag{2}$$

where, GM is the Gross Margin, TR is the Total Revenue, NR is the Net Return; TFC is the Total Fixed Cost, and TVC is the Total Variable Cost.

2.4.1. Probit Regression Analysis of Factors Influencing the Decisions of Participants to Utilize Their Lands for Cultivating Indigenous Fruits and Vegetables

A probit regression model was fitted to assess the determinants of rural household's decision to utilize their land for cultivating indigenous fruits and vegetables. The model is the standard method for estimating a binary category dependent variable and, due to the dichotomous nature of the dependent variable, which is the dummy form of whether the participants decide to utilize their land for the cultivation of indigenous fruits and vegetables or not. Probit regression is a mathematical modeling approach that can be used to describe the relationship of several independent variables to a dichotomous dependent variable, also called a probit model, being used to model dichotomous or binary outcome variables [28,29].

In the probit model, the inverse standard normal distribution of the probability is modeled as a linear combination of the predictors. The probit model constrains the estimated probabilities to be between 0 and 1 and relaxes the constraint that the effect of independent variables is constant across different predicted values of the dependent variable [30,31]. The probit model assumes an S-shaped response curve, such that in each tail of the curve, the dependent variable responds slowly to changes in the independent variables, while towards the middle of the curve, i.e., towards the point where Pr(Yi = 1) is closest to 0.5, the dependent variable responds more swiftly to changes in the independent variables. The probit model assumes that, while we only observe the values of 0 and 1 for the variable Y, there is a latent, unobserved continuous variable that determines the value of Y. We assume that Y can be specified as follows:

$$Yj = \alpha + \beta j \sum_{i=1}^{n} Ij + uj' \tag{3}$$

$$\mathrm{P_i} = \alpha_{\mathrm{o}} + \alpha_{1\mathrm{X1}} + \alpha_2\mathrm{X}_2 + \alpha_3\mathrm{X}_3 + \alpha_4\mathrm{X}_4 + \alpha_5\mathrm{X}_5 + \alpha_6\mathrm{X}_6 + \alpha_7\mathrm{X}_7 + \alpha_8\mathrm{X}_8 + \alpha_9\mathrm{X}_9 + \alpha_\mathrm{n}\mathrm{X}_\mathrm{n} + \ldots + {}_{\mathrm{ei}} \tag{4}$$

where Y_j is the binary dependent variable indicating the decision of participant's to cultivate indigenous fruits and vegetables on their lands. The dummy variable is 1 if yes and 0 if otherwise. The α and β are the parameters of the estimates. The n is the number variables. The μ_j is the error term while I_j is the independent variables (Table 2). Thus, the null hypothesis indicates that there is no significant relationship between the socioeconomic characteristics and decision of households to cultivate indigenous fruits and vegetables on their land.

Table 2. Variables influencing the decision of participants to cultivate indigenous fruits and vegetables on their land.

Variables	Description and Measurement Units
Age	Age of the participant (in completed years)
Marital status	Marital status of the participant? (1 = married, 0 = otherwise)
Educational status	Years of formal schooling? (in completed years)
Other occupation	Other occupation of the participant apart from farming? (1 = yes, 0 = no)
Ethnicity	Ethnic group of the participant? (1 = Yoruba, 0 = otherwise)
Household size	Number of household members? (head count)
Years of experience	Experience in farming? (number of years)
Storage technique	Storage method of the product? (1 = basket, 0 = otherwise)
Nutritional benefit	Nutritional advantage of indigenous plants? (1 = yes, 0 = no)
Drought-resistant benefit	Drought-resistant advantage of indigenous plants? (1 = yes, 0 = no)
Low input requirement benefits	Low input advantage of indigenous plants? (1 = yes, 0 = no)
Pest and disease benefits	Pest- and disease-resistant advantage of indigenous plants? (1 = yes, 0 = no)
Financial return	Total value of revenue from indigenous plant production in Naira (continuous)
Membership of cooperative society	Participant's cooperative membership? (1 = yes, 0 = no)
Customer access to farm	Can potential buyers have access to the farm? (1 = yes, 0 = no)
State of infrastructure	Does the farmland have necessary infrastructure? (1 = yes, 0 = no)
Financial gain	Is indigenous plant cultivation profitable? (1 = yes, 0 = no)
Transportation cost	Total value of transportation during production in Naira (continuous)
Labour cost	Total labour production in Naira (continuous)
Established market	Is there market for the indigenous plants produced? (1 = yes, 0 = no)
Road availability	Is there accessible road leading to the farm? (1 = yes, 0 = no)
Access to government subsidies	Do you have access to government subsidies? (1 = yes, 0 = no)

2.4.2. Principal Component Analysis of the Livelihood Asset Index Generation

In this study, Principal Components Analysis (PCA) was used to compute composite indices of the household's livelihoods from the sustainable livelihood questions (Table 3). This approach helps capture the different dimensions of the household's livelihood assets in a composite manner, bearing in mind the likely correlation that could exist among some variables. To allow for equal weighting across the measures of livelihood, five questions from each of the sustainable livelihood indicators were selected. The selection of the indicator was guided by insights drawn from the livelihood asset literature as well as the availability of data [32–34]. All the major dimensions of a sustainable livelihood were represented by at least four indicators. A livelihood asset variable (PCA-based livelihood index) was generated. The variables selected for constructing the livelihood index were the five sustainable livelihood categories coded as 1 if yes and 0 if otherwise, the categories being human capital, natural capital, social capital, financial assets, and physical capital assets; it was computed as follows:

$$\text{Livelihood index} = \varnothing_{\mathrm{i}} + \beta_{\mathrm{i}} \sum_{n=1}^{C} N_{\mathrm{ir}} + z_{\mathrm{v}} \tag{5}$$

where the livelihood index is the composite index, $\varnothing_{\mathrm{i}}$, and β_{i} represents the parameters to be estimated. However, N_{ir} represents the vector of variables and z_{v} represents the error term. The study then used the index generated by the PCA as the outcome variable in the propensity score matching model employed for the impact of cultivating indigenous fruits and vegetables on their livelihoods using propensity score matching.

Table 3. Dummy variable used to generate composite livelihood asset indices.

Livelihood Assets of Households	Description	Mean
Human Capital		
Do you have vocational training in indigenous fruits and vegetables?	Dummy	0.73
Technical training on how to cultivate indigenous fruits and vegetables?	Dummy	0.55
Marketing skill on indigenous fruits and vegetables?	Dummy	0.535
Do you have innovative product(s) from indigenous fruits and vegetables?	Dummy	0.441
Do you have access to a government agent for on-the-job training or follow-ups?	Dummy	0.303
Natural Capital		
Do you have access to land?	Dummy	0.317
Do you utilize the land for indigenous fruits and vegetables?	Dummy	0.308
Do you have access to water?	Dummy	0.358
Do you have or own livestock?	Dummy	0.421
Social Capital		
Networking with another indigenous fruit and vegetable sellers?	Dummy	0.458
Networking with relevant government ministry?	Dummy	0.754
Do you network with international organizations or another farmer cooperative?	Dummy	0.510
Do you network with professional memberships and organizations such as the National Fadama Development Project (NFDP), Agricultural Development Programme (ADP)?	Dummy	0.487
Are you part of any trade unions?	Dummy	0.352
Do you network with village or community committees?	Dummy	0.234
Financial Capital		
Access to banks and cooperatives?	Dummy	0.425
Personal savings?	Dummy	0.225
Access to government subsidies or grants?	Dummy	0.692
Access to money from relatives?	Dummy	0.525
Networking with financial institutions?	Dummy	0.340
Physical Capital		
Is there an established market for indigenous fruits and vegetables?	Dummy	0.448
Are roads accessible?	Dummy	0.795
Telephone infrastructure?	Dummy	0.817
Access to private vehicle or other means of transportation?	Dummy	0.320
Ease of access to customers?	Dummy	0.317

2.4.3. Impact of Cultivating Indigenous Fruits and Vegetables on their Livelihoods Using Propensity Score Matching

The concept of propensity score matching (PSM) was first introduced by Rosenbaum and Rubin [35]. As a program evaluation technique, PSM compares the outcomes of program participants with 'equivalent' non-participants [36]. As the two groups are comparable, based on the observed characteristics, with the exception of program participation, the differences in the outcomes are assumed to be attributed to the program. The estimated propensity score for subject $e(x_i)$, (i = *1, . . . , N*) is the conditional probability of being assigned to a particular treatment, given a vector of observed covariates x_i [35]:

$$e(x_i) = \Pr\,(z_i \;=\; 1 \;\; \mathrm{x_i}) \tag{6}$$

and

$$\Pr(Z_i, \ldots, X_1, \ldots X_n) = \sum_{i=1}^{N} e\{X_i\}^{Zi}\{1 - e\{X\}^{1-Zi} \tag{7}$$

where z_i is 1 for treatment, z_i is 0 for control, and x_i is the vector of observed covariates for the $\mathrm{i^{th}}$ subject.

The propensity score is a probability, ranging in values from 0 to 1, with matching used in a randomized experiment comparing two groups, ideally scoring each participant as 0.50. This is because each participant would be randomly assigned to either the treatment or the control group, with a 50% probability. In this study, PSM was used to evaluate the impact of cultivating indigenous fruits and vegetables on the livelihood of the households and enables the calculation of the mean effect of their cultivation on the participants. If $\mathrm{Y_1}$ denotes the potential outcome conditional on indigenous fruit and vegetable cultivation and $\mathrm{Y_0}$ denotes the potential outcome conditional on non-cultivation of indigenous fruits and vegetables, the impact of a program is given by:

$$\Delta = \mathrm{Y_1} - \mathrm{Y_0} \tag{8}$$

2.4.4. Estimating the Impact (Average Treatment Effect on the Treated)

The matched sample was used to compute the Average Treatment Effect for the treated (impact). It is estimated as follows:

$$\mathrm{ATT} \;=\; \mathrm{E}(\Delta \,|\, \mathrm{D} \;=\; 1,\, \mathbf{X}) \;=\; \mathrm{E}(\mathrm{Y_1} \;-\; \mathrm{Y_0} \,|\, \mathrm{D} \;=\; 1,\, \mathbf{X}). \tag{9}$$

$$= \mathrm{E}(\mathrm{Y_1} \,|\, \mathrm{D} \;=\; 1,\, \mathbf{X} \;-\; \mathrm{E}(\mathrm{Y_0} \,|\, \mathrm{D} \;=\; 1,\, \mathbf{X}) \tag{10}$$

where D = 1 denotes an indigenous fruit- and vegetables-cultivating household (treatment) and **X** is a set of conditioning variables on which the subjects were matched. Equation (8) would have been easy to estimate except for the equation E ($\mathrm{Y_0}$ | D = 1, **X**). This is the mean of the counterfactual and denotes what the outcome would have been among participants had they not participated in the treatment, with PSM providing a way of estimating this equation.

$$\mathrm{ATT} \;=\; \mathrm{E}[\mathrm{Y_1} \,|\, \mathrm{D} \;=\; 1,\, \mathrm{P(X)}] \;=\; \mathrm{E}[\mathrm{Y_0} \,|\, \mathrm{D} \;=\; 0,\, \mathrm{P(X)}] \tag{11}$$

Equation (10) is applicable to single programs where the treatment variable is categorical with only two mutually exclusive categories, although the equation is easily generalized to multiple programs [37–39]. The ATE, i.e., the average effect of the treatment for an individual drawn at random from the overall population at random, is:

$$\mathrm{ATE} = \frac{\mathrm{N_1}}{\mathrm{N}} \times \mathrm{ATT} + \frac{\mathrm{N_0}}{\mathrm{N}} \times \mathrm{ATU} \tag{12}$$

where $\mathrm{N_1}$ is the number in the treatment group and $\mathrm{N_0}$ is the number in the control group. The above equation shows the relationship between ATT (average treatment on the treated), ATE (average treatment effect on an individual), and ATU (average treatment on the untreated). The null form of the set hypothesis was that there is no significant relationship between the impact of cultivating indigenous fruits and vegetables and the livelihood of households in the study area.

2.5. Ethical Approval

The ethical clearance (certificate no: NWU-01771-20-A9) for the research was approved and designated as a minimal risk by the Faculty of Natural and Agricultural Sciences Research Ethics Committee (FNASREC), North-West University, South Africa. The rule of voluntary participation and withdrawal of the participant at any given time was observed. Furthermore, the principle of privacy, autonomy, dignity, and respect was observed all through the study.

3. Results and Discussion

3.1. Socioeconomic Characteristics versus Land Utilization Status of the Participants

Table 4 represents the descriptive results of the variables used in the probit regression model. The dependent variable is the total farm revenue of the indigenous fruits and vegetables, measured in Naira (Nigerian currency: USD 1 = NGN 450 during the survey period of September–November 2021). About 69.25% of the participants cultivate indigenous fruits and vegetables on their lands. The average total revenue (NGN 72,345.53) made from farming was significantly higher among those who cultivated indigenous fruits and vegetables than the participants who did not (NGN 55,888.99). This translates into a 29.40% increase in the average total farm revenue by those who cultivate indigenous fruits and vegetables relative to participants who do not.

Demographic characteristics of the participants showed that 60.50% of the farmers were male while 39.50% were females in the study area. Males are often more involved in agriculture than their female counterparts. This also corroborates with the findings from several studies that males were more likely to cultivate indigenous plants than females [13,40,41].

The average age of the participant was 50.25 years with 41.80% of the participants within the age category of 48–57 years. This is in line with the findings by Omotayo [42], who suggested that the age bracket is the economically active age and, as such, will respond positively to livelihood intervention aimed at improving the productive capacity of rural households. Furthermore, the marital status of the participants showed that 86% were married while singles, divorced, and widow(er)s comprised 4.67% each. This is a good indicator of the possibility of an improved livelihood because the family members of the married participants have the probability of assisting in the cultivation of the indigenous fruits and vegetables. Hence, the lower production cost and higher revenue allow for a better livelihood among the indigenous plant farmers in the study area. Furthermore, the availability of family labour reduces labour constraints faced during the peak of the farming season, which, if not properly managed, may lead to an increase in the production costs for indigenous plants in the study area.

In terms of formal educational attainment of the participants (Figure 2), secondary/high school education was the most (42.00%) dominant level. This shows a considerably low level of formal education among the participants. Educational attainment has been confirmed as a viable contributor to the productivity of farmers as this could assist them in understanding the dynamics of the farming enterprise [29,42–45]. Educational attainment could also help the participant stand a good chance of embracing new innovations in cultivating indigenous fruits and vegetables in the study area.

An average household size of six was observed in the study, with 56% of the families having 6–10 members. As agricultural production activities are labour intensive, large households can provide farm labour at little or no direct cost [27,42]. The participants were mainly of the Yoruba tribe (88.30%) due to the location of the study area. This is line with Ajibefun [25], who indicated that the native language of the people of the

Akure land in Ondo state is Yoruba. Their cultural dominance and land ownership will result in their cultivating the indigenous fruits and vegetables of their choice, without being mindful of restrictive lease or rental conditions. The average years of experience of the participants cultivating indigenous fruits and vegetables was 19.16 years. This indicates that most families have been farming for a long time, and the accumulated years of experience will help them to plant, mitigate climate change adaptation strategies, have good seasonal knowledge, and be familiar with pest and disease control, agronomic, and technical problems in farming, *ceteris peri bus* [27].

Table 4. Socioeconomic characteristics disaggregated by land utilization status of participants from the selected areas of Ondo State, Nigeria. SD = standard deviation.

Variable	**Pooled (*n* = 400)**		**Indigenous Plant Farmers (*n* = 277)**		**Non-Indigenous Plant Farmers (*n* = 123)**	
Outcome Variable	Mean	SD	Mean	SD	Mean	SD
Total farm revenue	64,117.3	50,130.93	72,345.53	58,743.86	55,888.99	41,201.2
Livelihood index	3.42×10^{-9}	2.107	−0.84990	1.42101	1.9018	2.1541
Socioeconomic Variables						
Gender	0.395	0.4894	0.3935	0.48941	0.39837	0.49156
Age	50.25	9.582	50.1264	9.0835	50.528	10.655
Marital status	1.07	0.513	1.0974	0.51908	1.016	0.49561
Educational status	1.15	1.405	1.0722	1.41748	1.3414	1.366
Other occupation	1.65	3.35	1.8014	3.7783	1.333	2.075
Ethnicity	0.175	0.55	0.18050	0.53492	0.1626	0.5919
Household size	6.075	2.258	5.9097	2.1099	6.447	2.532
Years of experience	19.16	10.619	18.144	10.106	21.447	11.4076
Storage techniques	0.36	0.481	0.36101	0.48116	0.3577	0.48129
Nutritional benefit	3.278	0.698	3.3357	0.64767	3.1463	0.78597
Drought-resistant benefit	2.71	1.046	2.7039	1.0763	2.7235	0.97762
Low input requirement benefit	2.669	1.148	2.9205	0.9673	2.0983	1.3136
Pest and disease benefits	2.817	0.949	2.78339	0.94217	2.8943	0.96507
Financial return	0.105	0.307	0.06859	0.25321	0.18699	0.3914
Membership of cooperative society	0.305	0.461	0.27797	0.44881	0.36585	0.4836
Customer access to farm	0.163	0.369	0.10507	0.30720	0.29268	0.45685
State of infrastructure	1.492	0.592	1.4693	0.58665	1.5447	0.60397
Financial gain	0.237	0.443	0.2346	0.44942	0.2439	0.43119
Transportation cost	1628.82	2881.0	1437.688	2256.516	2057.7	3915.8
Labour cost	1021	9049.40	10,476.53	9236.447	9632.52	8621.375
Established market	0.34	0.4743	0.20577	0.40499	0.64227	0.48129
Road availability	0.52	0.5002	0.45126	0.49851	0.67479	0.47036
Access to government subsidies	0.692	0.462	0.649819	0.47788	0.78861	0.78861

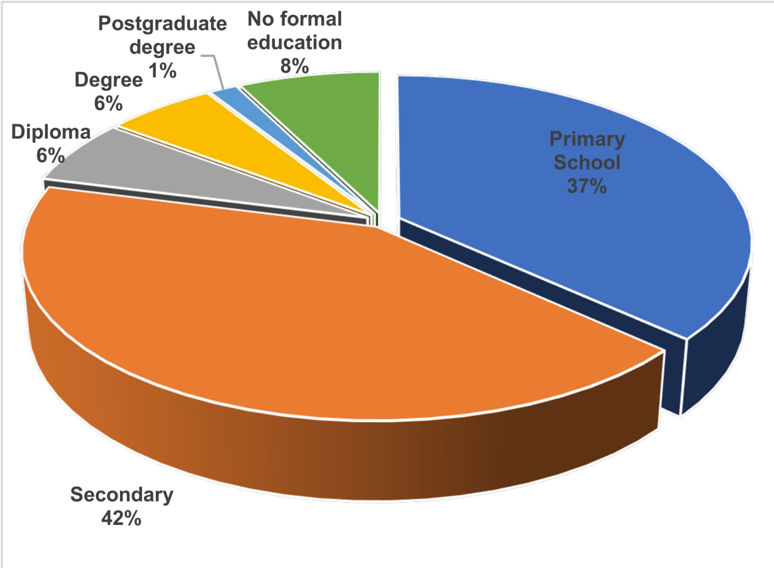

Figure 2. Educational attainment of participants in Ondo State, Nigeria (n = 400).

3.2. Land Utilization and Total Farm Revenue

The variables and their descriptive statistics, including mean and standard deviations (SD), are presented in Table 4, and include the disaggregated indigenous and non-indigenous plant farmers' statistics. The data revealed significant differences across the variables between the two groups. Farmers (69.25%) cultivating indigenous fruits and vegetables possibly invested less on production inputs, including labour and pest and disease management, compared to the farmers not involved with indigenous plants, thereby generating more revenue than their counterparts. Figure 3 shows the farmers' kernel density distributions of total revenue as being disaggregated by their land utilization status. Cox [46] provided a detailed description on kernel density. The natural log (ln) of the average total revenue made from farming was significantly higher among those who cultivated indigenous fruits and vegetables than the participants who did not. Observable differences were noted between the two groups, which corroborates the literature that cultivating indigenous fruits and vegetables contributes to the income and livelihood of people in rural areas [13,28]. However, this study demonstrated this further because the previous evidence did not adjust for bias from unobservable factors. Furthermore, this difference in the two groups of farmers may indicate unobservable factors that can affect production risks differently, justifying the basis for the choice of the propensity score matching model for the analyses.

3.3. Gross Margin Analysis Result

Gross margin is the different between the Total Revenue (TR) and the Total Variable Cost (TVC). It is a useful planning tool in situations where fixed capital is a negligible portion of the indigenous fruit and vegetable enterprise.

Therefore,

$$GM = TR - TVC = NGN\ 64,117.3 - NGN\ 35,379.50 = NGN\ 28,737.8/Ha \quad (13)$$

In addition,

$$Net\ Return/Profit = GM - TFC = NGN\ 28,737.8 - NGN\ 9,550 = NGN\ 19,187.8/Ha \quad (14)$$

The profitability analysis of the indigenous fruits and vegetables revealed that the Gross Margin of the rural farmers in the Akure South local government area of Ondo State, Nigeria, is NGN 28,737.8/Ha, with the profitability being NGN 19,187.8/Ha. These figures indicate that the cultivation of indigenous fruits and vegetables is profitable, which supports existing literature [47–50]. However, the profitability level remains small, probably due to a lack of adequate recognition of the importance of indigenous fruits and vegetables among consumers, which is capable of reducing the demandvhence, lower income and profit from the indigenous plants. In addition, the low profitability rate could be due to the productivity level of the varieties that are available, which are mainly indigenous, with plant breeding and scientific improvement possibly helping to improve their yield/Ha, productivity, and profitability, which transfer into a better livelihood for the rural farmers [51,52].

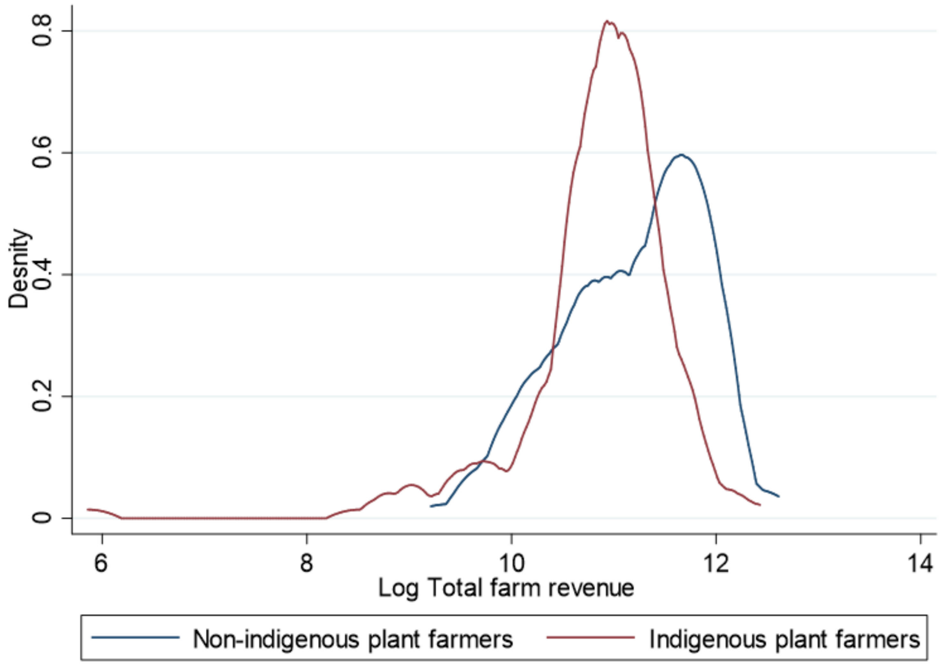

Figure 3. Kernel density distributions of total revenue disaggregated by land utilization.

3.4. Factors Influencing Their Decision to Utilize Lands to Cultivate Indigenous Fruits and Vegetables

Studies on factors influencing the decisions of farmers to cultivate indigenous plants remain relatively scarce in Nigeria, specifically fruit and vegetable cultivation. The average marginal effects were estimated and reported to ensure the results are better interpreted [53]. The measures of goodness of fit for the model, such as the Wald chi^2 and Pseudo R^2, were calculated (Table 5). According to the diagnostic measures utilized in the study, the model is regarded as a good fit. The utilized variables were subjected to a multicollinearity test, which was conducted with a variance inflation factor (VIF) of 1.47, which indicated that there was an absence of serious multicollinearity in the analysis. Given that many variables that captured the socioeconomic factors and the decision of participants to utilize their land to cultivate indigenous plants had different levels of statistical significance, the null hypothesis was rejected.

In this study, the marital status of the participants was negative and significant ($p < 0.1$), which indicated that this status decreased their probability of deciding to cultivate indigenous fruits and vegetables. The coefficient of their educational attainment was positive and significant ($p < 0.05$) *Ceteris peri bus*. In addition, households with higher levels of education had a 0.037 probability of cultivating indigenous fruits and vegetables in the study area. Education facilitates the ability to explore and acquire new information, such as new plant cultivation techniques, access to market, and input prices as well as cost and returns [28,54]. Their education status may influence their decision to use their land to cultivate indigenous fruits and vegetables in the study area.

Table 5. Probit regression result of factors influencing the decision of participants to utilize their lands to cultivate indigenous fruits and vegetables.

Variable	Coefficient	Robust Std. Error	t	$p > \lvert t \rvert$	Tolerance	Marginal Effect	Robust Std. Error
Age	−0.0048	0.0115	−0.42	0.676	0.4679	−0.00152	0.0036
Marital status	−0.3690	0.1891	−1.95	0.051 *	0.8802	−0.1173	0.0596
Educational status	0.1165	0.0577	2.02	0.044 **	0.9051	0.03704	0.0184
Other occupation	−0.0687	0.0227	−3.03	0.002 ***	0.9236	−0.0218	0.0072
Ethnicity	−0.2022	0.1576	−1.28	0.200	0.8152	−0.0643	0.0502
Household size	−0.0463	0.0455	−1.02	0.310	0.6707	−0.0147	0.0144
Years of experience	0.0152	0.0114	1.34	0.182	0.4234	0.0048	0.0036
Storage technique	0.2004	0.1971	1.02	0.309	0.7193	0.06487	0.0648
Nutritional benefit	0.2833	0.1388	−2.04	0.041 **	0.7912	−0.09009	0.0439
Drought-resistant benefit	0.1346	0.0974	1.38	0.167	0.5699	0.0428	0.0310
Low input requirement benefit	0.3619	0.0818	4.43	0.000 ***	0.6575	0.1150	0.0257
Reduced pest and disease benefits	0.2236	0.1192	1.88	0.061 *	0.6035	0.0711	0.0372
Financial return	0.7789	0.2575	3.02	0.002 ***	0.7878	0.2843	0.0996
Membership of cooperative society	−0.0970	0.2009	−0.48	0.629	0.6561	−0.0304	0.0623
Customer access to farm	1.0724	0.2457	4.36	0.000 ***	0.6524	0.3910	0.091
State of infrastructure	0.3652	0.1519	2.40	0.016 **	0.7749	0.1161	0.0476
Financial gain	0.4319	0.2426	1.78	0.075 *	0.6971	0.1373	0.0768
Transportation cost	0.0000	0.0000	2.05	0.041 **	0.6304	0.0000	0.0000
Labour cost	−0.0000	0.0000	−2.07	0.038 **	0.6178	-7.15×10^{-6}	0.0000
Established market	0.8331	0.1743	4.78	0.000 ***	0.7326	0.2811	0.0593
Road availability	0.2654	0.1798	1.48	0.140	0.7248	0.08395	0.0562
Access to government subsidies	0.3235	0.1885	1.72	0.086 *	0.7946	0.0983	0.0539
Constant	−0.4081	0.8100	−0.50	0.614			
Number of observations	400						
Wald chi^2 (22)	136.91						
Prob > chi^2	0.0000						
Pseudo R^2	0.3301						
Log pseudolikelihood	−164.064						
Mean Variance Inflation Factor (VIF)	1.47						

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The probability of another occupation (civil servants, traders, apprentice) for the participants was negative and significant ($p < 0.01$). This implies that having other occupations in the selected rural areas decreased the possibility of the farmers deciding to cultivate indigenous fruits and vegetables significantly. This might be due to time constraints and the time demand of farming, making it difficult to have another occupation. In addition, poor awareness on the lucrativeness of the enterprise could also deter or reduce their decision to cultivate indigenous plant varieties. This conformed to the findings by Omotayo and Aremu [12] that there is a need for the awareness of the nutritional and economic advantages of many indigenous plants. The coefficient on knowledge of the nutritional benefit of indigenous fruits and vegetables among the participants was significant ($p < 0.01$) and positive. Knowledge of their benefits has the probability of increasing the decision to utilize their land for cultivating indigenous products.

Another important factor that influences the decision of participants to use their land to cultivate indigenous fruits and vegetables is the knowledge of the associated low input requirement, with these households being more likely to use their land for its cultivation. This was expected, given that many rural small-holder farmers often need to minimize their cost of production and, therefore, their profit. Furthermore, the farmers with knowledge on the low-cost inputs associated with indigenous fruits and vegetables have the probability of cultivating these plants, as this leads to higher farm revenue and profit.

Knowledge about the low level of pests and diseases associated with indigenous fruits and vegetables was significant ($p < 0.1$) and was found to influence their decision to cultivate indigenous fruits and vegetables. A unit increase in the knowledge of these rural farmers was more likely to marginally result in a 0.0711 increase in the probability of farmers deciding to cultivate indigenous fruits and vegetables.

In terms of the knowledge of the financial returns from the cultivation of indigenous fruits and vegetables, a positive and significant ($p < 0.01$) value was recorded. This knowledge is capable of increasing their probability of using their land for the cultivation of indigenous fruits and vegetables. This further translated into the fact that a unit increase in the knowledge of financial return from cultivating indigenous fruits and vegetables by the participants led to a 0.2843 increase in the probability of using their farmland for such cultivation. Additionally, the variables representing customer access to the farm and the state of infrastructure were positive and significantly ($p < 0.01$ and $p < 0.05$ respectively) influenced the decision to cultivate indigenous fruits and vegetables. This suggests that farmers with better knowledge about the access of customers to the farm and the importance of good infrastructure are more likely to use farmland for cultivating indigenous fruits and vegetables. The purpose of these two variables is to enhance the production and marketing of the plants, as described in existing literature [55,56].

The coefficients of the financial gains from cultivating indigenous fruits and vegetables as well as the transportation cost were positive and significant ($p < 0.1$ and $p < 0.05$, respectively). This implies that knowledge about the financial gains and transportation cost from cultivating indigenous fruits and vegetables has the probability of influencing their decision to use their land for cultivating indigenous plants. This was expected, as adequate knowledge is essential before investing in any business venture, with this knowledge guiding the farmers to achieve their goal of making profit. The results marginally indicated that a unit increase in the financial gains of farmers from cultivating indigenous fruits and vegetables, as well as the transportation costs, will increase the probability of utilizing their farmland for cultivating indigenous fruits and vegetables in the study area. This aligns with the a priori expectation, as adequate knowledge of the possible financial gain and cost implications will aid the decision on delving into such business adventures.

Furthermore, the labour cost of producing indigenous fruits and vegetables was negative and significant ($p < 0.05$). In the study area, a reduction in the labour cost of production increased the probability of the farmers deciding to utilize their land to cultivate indigenous fruits and vegetables. This corroborates the a priori knowledge, as it is rational to decide in favour of their cultivating when the labour cost is lower, as this will increase the probability of higher profits from the enterprise and, hence, a better livelihood for the farmer [57–59].

In addition, the variable representing the knowledge of farmers about the established market for the indigenous fruits and vegetables was positive and significant ($p < 0.01$). This implied that the more knowledgeable the farmers were about the presence of a market for their produce, the higher will be their probability of deciding to utilize their farmland for the cultivation of indigenous plants. This was expected, as knowledge of market availability is key to production of agri-produce, especially in the case of perishable produce, such as fruits and vegetables [60,61]. Finally, the coefficients of access to government subsidies by participants was positively significant ($p < 0.1$). An increase in access to government subsidies by the farmers has the probability of enhancing their decision to cultivate indigenous fruits and vegetables in the study area. This was expected, as access to government subsidies/support to access viable seeds, chemicals, and fertilizers could encourage the farmers to use their land to cultivate indigenous fruits and vegetables. This often translate into a better income and improved livelihood among the rural farmers [62].

3.5. Impact of Cultivating Indigenous Fruits and Vegetables on Livelihood Outcome of Farmers'

The estimated average impact of cultivating indigenous fruits and vegetables on livelihood outcomes (livelihood and average farm revenue) of households was denoted by the Average Treatment Effect for the treated (impact) (ATE), with the impact parameter suggesting that cultivating indigenous fruits and vegetables will increase livelihood and farm revenue of farmers by NGN 2265 and NGN 17,604.85, respectively. Levels of a 120.70% and 24.30% increase in livelihood outcomes were recorded as a result of cultivating indigenous fruits and vegetables for livelihood and farm revenue, respectively (Table 6 and Figure 4). Therefore, the null hypothesis was rejected as the result was congruence with the descriptive findings of this research, i.e., that the farming households that cultivate indigenous fruits and vegetables have better average farm revenue and livelihoods than those who do not. This corroborates the literature that the cultivation of indigenous plants contributes to livelihood improvement of households [16,63,64].

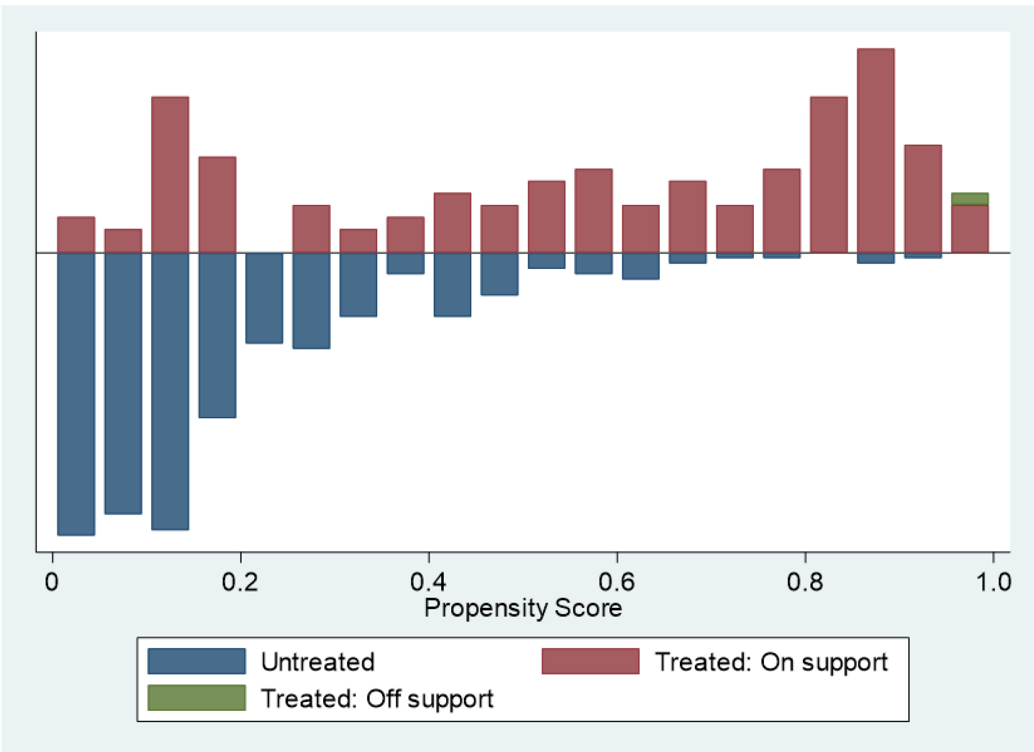

Figure 4. Density of the propensity scores and common support for indigenous fruit and vegetable farmers relative to non-indigenous fruit and vegetable farmers.

Table 6. Propensity score matching results of the impact of cultivating indigenous fruits and vegetables on households' livelihood outcomes.

Outcome Variables	Sample	Treated	Controls	Difference	T-Stat
Livelihood	Unmatched	1.89110243	−0.849916718	2.74101915	14.87
	ATT	1.87670221	−0.388338309	2.26504052	6.12
Average farm revenue	Unmatched	72,717.2131	35,931.8182	36,785.3949	7.14
	ATT	72,574.3802	54,969.527	17,604.8531	1.68

4. The Study Limitations

The study relied solely on the information from 400 selected rural indigenous and non-indigenous fruit- and vegetable-cultivating households in the Akure South local government area and not the entire Ondo State. In addition, out of the 320 communities in the Akure South local government area, 40 were selected, which cannot be taken as a general representation of the knowledge of the impact of indigenous fruits and vegetables on household livelihood in Ondo state and Nigeria as a whole. The current study focused on farmers and knowledge holders in the selected communities and not the entire populace.

5. Conclusions and Recommendations

Based on the observed farming practices in the study area, the cultivation of indigenous fruits and vegetables should be encouraged to improve the livelihoods and rural development of farming households in Nigeria. Policies that seek to promote the livelihood of small-holder farming households need to recognize and support the cultivation of indigenous fruits and vegetables rather than the naturally imposed, narrowly framed rural economic growth narrative that can potentially erode the food complementarities of indigenous fruits and vegetables. The findings emphasized the role of educational attainment, government subsidies, and knowledge of the nutritional benefit of the indigenous fruits and vegetables as key determinants for farmers to decide about their cultivation. Kernel distribution revealed that the natural log (ln) of the average total revenue made from farming was significantly higher among those who cultivated indigenous fruits and vegetables than the participants who did not. In addition, the study affirmed that cultivating indigenous fruits and vegetables has the potential to increase livelihood and farm revenue by NGN 2265 and NGN 17,604.85, respectively. Likewise, livelihood and farm revenue generated levels of a 120.70% and 24.30% increase, respectively.

The conditions necessary for enabling poor households to explore the benefits of cultivating indigenous fruits and vegetables needs to be encouraged and prioritized in the rural communities of Nigeria. Policies that tend to prioritize intensified and commercialized cultivation of indigenous fruits and vegetables as complementarities for the livelihood of farming households should be encouraged. If farming households are to be supported in improving their livelihood, sufficient land for cultivation should be given priority in rural development and agricultural policies. Policy interventions targeted towards strengthening the biotechnological advancement of indigenous fruits and vegetables remain pertinent. This will contribute toward novel strategies for producing suitable indigenous plant genotypes that are capable of resisting drought, high temperature, submergence, and salinity stresses, thereby improving their cultivation and production. Furthermore, there is need for policies that are directed towards enhanced awareness programs, improved access to affordable financing options, and the provision of incentives for the cultivation of indigenous fruits and vegetables.

Author Contributions: Conceptualization, S.F.O., A.O.O., I.O.L. and A.O.A.; methodology, A.O.O.; resources, A.O.O., I.O.L. and A.O.A.; Writing—Original Draft Preparation, S.F.O. and A.O.O.; Writing—Review and Editing, A.O.O., I.O.L. and A.O.A.; Supervision, A.O.O., I.O.L. and A.O.A.; project administration, A.O.O., I.O.L. and A.O.A.; funding acquisition, I.O.L. and A.O.A. The final version of

the manuscript has been read and approved by all authors. All authors have read and agreed to the published version of the manuscript.

Funding: Adeyemi Oladapo Aremu received research funds from the National Research Foundation (NRF, Pretoria, South Africa) in the form of the Knowledge Interchange and Collaboration: African Interaction (NRF Grant UID: 138253). The APC was funded by the Faculty of Natural and Agricultural Sciences, North-West University, South Africa.

Institutional Review Board Statement: This research was approved (NWU-01771-20-A9) by the Faculty of Natural and Agricultural Sciences Research Ethics Committee (FNASREC) of the North-West University, South Africa.

Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: All data used for this study are included in the article.

Acknowledgments: We appreciate the staff of Forest herbarium Ibadan of the Forestry Research Institute of Nigeria (FRIN), Ibadan, Oyo state, Nigeria, for assisting in the identification and preparation of the voucher specimen for the selected indigenous fruits and vegetables.

Conflicts of Interest: The authors declare that there is no conflict of interest. The funders (NRF and NWU) had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Knickel, K.; Redman, M.; Darnhofer, I.; Ashkenazy, A.; Chebach, T.C.; Šūmane, S.; Tisenkopfs, T.; Zemeckis, R.; Atkociuniene, V.; Rivera, M. Between aspirations and reality: Making farming, food systems and rural areas more resilient, sustainable and equitable. *J. Rural Stud.* **2018**, *59*, 197–210. [CrossRef]
2. Dengerink, J.; Dirks, F.; Likoko, E.; Guijt, J. One size doesn't fit all: Regional differences in priorities for food system transformation. *Food Secur.* **2021**, *13*, 1455–1466. [CrossRef]
3. Mustafa, M.A.; Mabhaudhi, T.; Avvari, M.V.; Massawe, F. Transition toward sustainable food systems: A holistic pathway toward sustainable development. In *Food Security and Nutrition*; Elsevier: Amsterdam, The Netherlands, 2021; pp. 33–56.
4. Bouazza, A.B. Small and medium enterprises as an effective sector for economic development and employment creation in Algeria. *Int. J. Econ. Commer. Manag.* **2015**, *3*, 1–16.
5. Garbero, A.; Resce, G.; Carneiro, B. Spatial dynamics across food systems transformation in IFAD investments: A machine learning approach. *Food Secur.* **2021**, *13*, 1125–1143. [CrossRef]
6. Bongaarts, J.; FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2020. Transforming Food Systems for Affordable Healthy Diets*; FAO: Rome, Italy, 2020; p. 320.
7. Ruben, R.; Cavatassi, R.; Lipper, L.; Smaling, E.; Winters, P. Towards food systems transformation—Five paradigm shifts for healthy, inclusive and sustainable food systems. *Food Secur.* **2021**, *13*, 1423–1430. [CrossRef]
8. Ribeiro, H.; Jaime, P.C.; Ventura, D. Alimentação e sustentabilidade. *Estud. Avançados* **2017**, *31*, 185–198. [CrossRef]
9. Gonçalves, C.D.B.Q.; Schlindwein, M.M.; Martinelli, G.D.C. Agroforestry systems: A systematic review focusing on traditional indigenous practices, food and nutrition security, economic viability, and the role of women. *Sustainability* **2021**, *13*, 11397. [CrossRef]
10. Imathiu, S. Neglected and underutilized cultivated crops with respect to indigenous African leafy vegetables for food and nutrition security. *J. Food Secur.* **2021**, *9*, 115–125. [CrossRef]
11. Awodoyin, R.O.; Olubode, O.S.; Ogbu, J.U.; Balogun, R.B.; Nwawuisi, J.U.; Orji, K.O. Indigenous fruit trees of tropical Africa: Status, opportunity for development and biodiversity management. *Agric. Sci.* **2015**, *6*, 31. [CrossRef]
12. Omotayo, A.O.; Aremu, A.O. Underutilized African indigenous fruit trees and food–nutrition security: Opportunities, challenges, and prospects. *Food Energy Secur.* **2020**, *9*, e220. [CrossRef]
13. Omotayo, A.O.; Ndhlovu, P.T.; Tshwene, S.C.; Aremu, A.O. Utilization pattern of indigenous and naturalized plants among some selected rural households of North West Province, South Africa. *Plants* **2020**, *9*, 953. [CrossRef]
14. Adebooye, O.; Ogbe, F.; Bamidele, J. Ethnobotany of indigenous leaf vegetables of Southwest Nigeria. *Delpinoa* **2003**, *45*, 295–299.
15. Maroyi, A. Traditional homegardens and rural livelihoods in Nhema, Zimbabwe: A sustainable agroforestry system. *Int. J. Sustain. Dev. World Ecol.* **2009**, *16*, 1–8. [CrossRef]
16. Kehlenbeck, K.; Asaah, E.; Jamnadass, R. Diversity of indigenous fruit trees and their contribution to nutrition and livelihoods in sub-Saharan Africa: Examples from Kenya and Cameroon. In *Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health*; FAO: Rome, Italy, 2013; pp. 257–269.
17. Shumsky, S.A.; Hickey, G.M.; Pelletier, B.; Johns, T. Understanding the contribution of wild edible plants to rural social-ecological resilience in semi-arid Kenya. *Ecol. Soc.* **2014**, *19*, 1–21. [CrossRef]

18. Nnadi, F.; Chikaire, J.; Ezudike, K. Assessment of indigenous knowledge practices for sustainable agriculture and food security in Idemili South Local Government Area of Anambra State, Nigeria. *J. Resour. Dev. Manag.* **2013**, *1*, 1–8.
19. Wood, A.P.; Dixon, A.; McCartney, M.P. *Wetland Management and Sustainable Livelihoods in Africa*; Routledge/Earthscan from Routledge: Oxford, UK, 2013.
20. Leakey, R.R.; Tchoundjeu, Z.; Schreckenberg, K.; Shackleton, S.E.; Shackleton, C.M. Agroforestry tree products (AFTPs): Targeting poverty reduction and enhanced livelihoods. *Int. J. Agric. Sustain.* **2005**, *3*, 1–23. [CrossRef]
21. Cunningham, A.B. *Applied Ethnobotany: People, Wild Plant Use and Conservation*; Routledge: Oxford, UK, 2014.
22. Awoyemi, O.; Abdulkarim, I.; Ewa, E.; Aduloju, A. Ethnobotanical assessment of herbal plants in South-Western Nigeria. *Acad. Res. Int.* **2012**, *2*, 50.
23. Bassey, C.; Ikpi, L. Perception of utilitarian values of agrobiodiversity by rural farmers in Akwa Ibom State, Nigeria. *Afr. J. Agric. Res.* **2011**, *6*, 6622–6634.
24. Afolabi, O.J.; Akinneye, J.O.; Igiekhume, A.M. Identification, abundance, and diversity of mosquitoes in Akure South Local Government Area, Ondo State, Nigeria. *J. Basic Appl. Zool.* **2019**, *80*, 1–7. [CrossRef]
25. Daniel, O.A. Urban extreme weather: A challenge for a healthy Living environment in Akure, Ondo State, Nigeria. *Climate* **2015**, *3*, 775–791. [CrossRef]
26. Guest, G. Sampling and selecting participants in field research. *Handb. Methods Cult. Anthropol.* **2014**, *2*, 215–249.
27. Omotayo, A.O.; Oladejo, A.J. Profitability of cassava-based production systems. *J. Hum. Ecol.* **2016**, *56*, 196–203. [CrossRef]
28. Omotayo, A.O.; Aremu, A.O. Evaluation of factors influencing the inclusion of indigenous plants for food security among rural households in the North West Province of South Africa. *Sustainability* **2020**, *12*, 9562. [CrossRef]
29. Olagunju, K.O.; Ogunniyi, A.I.; Oyetunde-Usman, Z.; Omotayo, A.O.; Awotide, B.A. Does agricultural cooperative membership impact technical efficiency of maize production in Nigeria: An analysis correcting for biases from observed and unobserved attributes. *PLoS ONE* **2021**, *16*, e0245426. [CrossRef]
30. Ogunniyi, A.I.; Omotoso, S.O.; Salman, K.K.; Omotayo, A.O.; Olagunju, K.O.; Aremu, A.O. Socio-economic drivers of food security among rural households in Nigeria: Evidence from smallholder maize farmers. *Soc. Indic. Res.* **2021**, *155*, 583–599. [CrossRef]
31. Ogunniyi, A.; Omonona, B.; Abioye, O.; Olagunju, K. Impact of irrigation technology use on crop yield, crop income and household food security in Nigeria: A treatment effect approach. *Am. Inst. Math. Sci.* **2018**, *3*, 154–171.
32. Kaza, S.; Yao, L.; Bhada-Tata, P.; Van Woerden, F. *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*; World Bank Publications: Washington, DC, USA, 2018.
33. Omotayo, A.O.; Omotoso, A.B.; Daud, A.S.; Ogunniyi, A.I.; Olagunju, K.O. What drives households' payment for waste disposal and recycling behaviours? Empirical evidence from South Africa's general household survey. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7188. [CrossRef]
34. Rada, E.C.; Ragazzi, M.; Ionescu, G.; Merler, G.; Moedinger, F.; Raboni, M.; Torretta, V. Municipal solid waste treatment by integrated solutions: Energy and environmental balances. *Energy Procedia* **2014**, *50*, 1037–1044. [CrossRef]
35. Rosenbaum, P.R.; Rubin, D.B. The central role of the propensity score in observational studies for causal effects. *Biometrika* **1983**, *70*, 41–55. [CrossRef]
36. Rufai, A.M.; Ogunniyi, A.I.; Salman, K.K.; Salawu, M.B.; Omotayo, A.O. Rural transformation and labor market outcomes among rural youths in Nigeria. *Sustainability* **2021**, *13*, 13794. [CrossRef]
37. Imbens, G.; Hirano, K. The propensity score with continuous treatments. *Appl. Bayesian Model. Causal Inference Incomplete Data Perspect.* **2004**, *226164*, 73–84.
38. Lechner, M. Earnings and employment effects of continuous gff-the-job training in east Germany after unification. *J. Bus. Econ. Stat.* **1999**, *17*, 74–90. [CrossRef]
39. Lechner, M. Identification and estimation of causal effects of multiple treatments under the conditional independence assumption. In *Econometric Evaluation of Labour Market Policies*; Springer: New York, NY, USA, 2001; pp. 43–58.
40. Dadjo, C.; Nyende, A.B.; Salako, K.V.; Hounkpevi, A.; Assogbadjo, A.E. Socio–economic factors determining conservation and cultivation of *Garcinia kola* Heckel—A medicinal plant extinct in the wild in Benin. *Econ. Bot.* **2020**, *74*, 115–125. [CrossRef]
41. Nkonki-Mandleni, B.; Omotayo, A.O. Exploring the living conditions at Ezakheleni informal settlement, Durban Metropolis of KwaZulu-Natal, South Africa with an upscaling motive. *Int. J.* **2020**, *76*, 11.
42. Omotayo, A.O. Farming households' environment, nutrition and health interplay in Southwest, Nigeria. *Int. J. Sci. Res. Agric. Sci.* **2016**, *3*, 84–98. [CrossRef]
43. Zakaria, H. The drivers of women farmers' participation in cash crop production: The case of women smallholder farmers in Northern Ghana. *J. Agric. Educ. Ext.* **2017**, *23*, 141–158. [CrossRef]
44. Wu, C.C. Education in farm production: The case of Taiwan. *Am. J. Agric. Econ.* **1977**, *59*, 699–709. [CrossRef]
45. Daud, A.S.; Awoyemi, T.; Omotoso, A.B.; Omotayo, A.O. Human capital and income diversification among crop farmers in rural Oyo State, Nigeria. *J. Agribus. Rural Dev.* **2018**, *49*, 251–260. [CrossRef]
46. Cox, N.J. Speaking stata: Graphing distributions. *Stata J.* **2004**, *4*, 66–88. [CrossRef]
47. Ojiewo, C.; Tenkouano, A.; Hughes, J.; Keatinge, J. Diversifying diets: Using indigenous vegetables to improve profitability, nutrition and health in Africa. In *Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health', Earthscan*; Routledge: Oxford, UK, 2013; pp. 291–302.

48. Mvungi, H.; Laizer, A.; Lukumay, P.J.; Ochieng, J.; Ngoteya, G.; Dinssa, F.; Simon, J.E.; Govindasamy, R.; Ndinya, C.; Odendo, M. Profitability analysis of traditional African vegetable seeds production in Kenya. *J. Med. Act. Plants* **2020**, *9*, 281–288.
49. Halli, S.B.; Swamy, K.; Sankanur, M.; Yewale, A. Fruit-based agroforestry systems for food security and higher profitability. *Int. J. Farm Sci.* **2016**, *6*, 302–311.
50. Burkhart, E.P.; Jacobson, M.G. Transitioning from wild collection to forest cultivation of indigenous medicinal forest plants in eastern North America is constrained by lack of profitability. *Agrofor. Syst.* **2009**, *76*, 437–453. [CrossRef]
51. Grenz, J.H.; Sauerborn, J. The potential of organic agriculture to contribute to sustainable crop production and food security in Sub-Saharan Africa. *J. Agric. Rural Dev. Trop. Subtrop.* **2007**, *89*, 50–84.
52. Saxena, K.; Sharma, D.; Vales, M. Development and commercialization of CMS pigeonpea hybrids. *Plant Breed. Rev.* **2018**, *41*, 103–167.
53. Greene, W.H. *Econometric Analysis*; Pearson Education India: Delhi, India, 2003.
54. Schreinemachers, P.; Wu, M.-H.; Uddin, M.N.; Ahmad, S.; Hanson, P. Farmer training in off-season vegetables: Effects on income and pesticide use in Bangladesh. *Food Policy* **2016**, *61*, 132–140. [CrossRef]
55. Aubert, B.A.; Schroeder, A.; Grimaudo, J. IT as enabler of sustainable farming: An empirical analysis of farmers' adoption decision of precision agriculture technology. *Decis. Support Syst.* **2012**, *54*, 510–520. [CrossRef]
56. Doss, C.R. Analyzing technology adoption using microstudies: Limitations, challenges, and opportunities for improvement. *Agric. Econ.* **2006**, *34*, 207–219. [CrossRef]
57. Paudel Khatiwada, S.; Deng, W.; Paudel, B.; Khatiwada, J.R.; Zhang, J.; Su, Y. Household livelihood strategies and implication for poverty reduction in rural areas of central Nepal. *Sustainability* **2017**, *9*, 612. [CrossRef]
58. Fox, L.; Sohnesen, T.P. Household enterprises in Sub-Saharan Africa: Why they matter for growth, jobs, and livelihoods. *World Bank Policy Res. Work. Pap.* **2012**, *6184*, 1–55.
59. Kuivanen, K.; Alvarez, S.; Michalscheck, M.; Adjei-Nsiah, S.; Descheemaeker, K.; Mellon-Bedi, S.; Groot, J.C. Characterising the diversity of smallholder farming systems and their constraints and opportunities for innovation: A case study from the Northern Region, Ghana. *NJAS Wagening. J. Life Sci.* **2016**, *78*, 153–166. [CrossRef]
60. Shukla, M.; Jharkharia, S. Agri-fresh produce supply chain management: A state-of-the-art literature review. *Int. J. Oper. Prod. Manag.* **2013**, *33*, 114–158. [CrossRef]
61. Gardas, B.B.; Raut, R.D.; Cheikhrouhou, N.; Narkhede, B.E. A hybrid decision support system for analyzing challenges of the agricultural supply chain. *Sustain. Prod. Consum.* **2019**, *18*, 19–32. [CrossRef]
62. Muimba-Kankolongo, A. *Food Crop Production by Smallholder Farmers in Southern Africa: Challenges and Opportunities for Improvement*; Academic Press: Cambridge, MA, USA, 2018.
63. Tanimonure, V.A.; Naziri, D.; Codjoe, S.N.A.; Ayanwale, A.B. Underutilised indigenous vegetables for household dietary diversity in Southwest Nigeria. *Agriculture* **2021**, *11*, 1064. [CrossRef]
64. Muhanji, G.; Roothaert, R.L.; Webo, C.; Stanley, M. African indigenous vegetable enterprises and market access for small-scale farmers in East Africa. *Int. J. Agric. Sustain.* **2011**, *9*, 194–202. [CrossRef]