LIVING HEDGES AND HOUSEHOLD FOOD AND NUTRITION SECURITY IN COTE D'IVOIRE

ABSTRACT

Soil degradation is a major problem, especially for Ivorian rice farmers who grow rainfed rice on slopes or flood plains. To remedy this, some households are adopting agroforestry practices, in particular living hedgerows. This study analyzes the economic impact of the adoption of living hedgerows on the food and nutritional security of rice-growing households in Côte d'Ivoire. Data were collected from households in the regions of Tonkpi in the west, Poro and Tchologo in the north, using stratified random sampling, with each village considered as a stratum. Then, the two steps of the propensity score matching (PSM) method were used to identify, firstly, the factors involved in adopting living hedges and, secondly, to measure the effect of this adoption on household food and nutritional security. The results obtained from the propensity score matching analysis (PSM) indicate that the adoption of living hedges improves the food and nutritional security of adopters. The study therefore recommends improving human capital through training in the choice of rice-growing plots, raising awareness of the benefits of agroforestry practices and capacity-building for producers in the use of living hedges.

Key words: Rice-growing households; Food and nutritional security; Living hedges.

1. INTRODUCTION

Soil degradation due to erosion is a major problem, particularly in rural areas of Côte d'Ivoire where rice growing is predominantly rainfed (ADERIZ, 2022). In the west and north of the country, producers grow rice on slopes or flood plains using traditional cultivation practices. This soil degradation reduces production and the sustainability of rice cultivation (Lapar et al., 1999). In addition, homogeneous farms often have little natural habitat around them, leading to a loss of biodiversity and eco-system services on farms, including a reduction in the number of pollinators and other beneficial insects (Zhang et al. 2007). To counter this, growers are restoring field edges by creating living hedgerows (Williams et al. 2015).

Living hedgerows have enormous potential to contribute to biodiversity conservation, soil conservation and improvement, carbon emission reduction, water retention, flood mitigation and climate change mitigation for the farmer (Montgomery et al., 2020). Living hedgerows make an important potential contribution to agro-ecological transitions and an overall contribution to multifunctional agroecosystems with multiple welfare and livelihood benefits. This transition can underpin a transformation of the agricultural system towards food sovereignty (Tilzey, 2021).

In rural Côte d'Ivoire, traditional and expansive rice production often prevents farmers from incorporating more biodiversity into their cropping systems. Despite the benefits of hedgerow planting, adoption rates are low. What factors affect the adoption of hedgerows by small-scale farmers? What is the impact of hedgerow adoption on household food and nutritional security?

Several variables in the literature, ranging from the characteristics of the grower to his socio-economic environment and the characteristics of his plot, affect the adoption of living hedges. Some studies show that low plot slope, land tenure insecurity, low initial productivity and limited market access reduce incentives to adopt living hedges (Lapar et al., 1999). Brodt et al. (2008) demonstrate that it is possible to generate interest in hedgerows if cost-sharing assistance, community support and influential local leaders are available. They also suggest that information and capacity-building for growers could alleviate the fear of weeds. Levasseur et al (2009) show that agricultural production units using an improved living hedge generally have more manpower, more agricultural equipment and a larger animal herd than non-adopters. As for López-Felices et al (2022), they show that increased biological control efficiency, reduced pesticide use and potential economic and environmental benefits are factors affecting hedgerow adoption in south-eastern Spain. Lack of knowledge and confidence in the effectiveness of hedgerow management is an obstacle.

Generally speaking, studies have shown the link between agroforestry and food security. For Steffan-Dewenter et al (2007), agroforestry systems can increase agricultural productivity if their different components occupy complementary niches and if their connections are managed effectively. Frison et al. (2011) believe that solving the problem of food and nutritional security requires the adoption of many interdependent agricultural approaches, particularly with regard to improving the productivity of staple crops through agroforestry. For example, Malézieux (2013) argues that the range of crops can be significantly expanded by taking advantage of a wide variety of less-developed native foods that are often more abundant in forests and other wooded areas, plants that are less exploited and often richer in microflora, nutrients, fiber and protein than staple crops.

However, the link between the adoption of living hedgerows and household food and nutrition security is not clearly established in the economic literature. Long et al. (2017) show that in the case of California, hedgerows can improve crop pollination and pest control, resulting in a return on investment within 7 to 16 years, with no negative impact on food security. Karp et al. (2015) question the removal of surrounding vegetation to improve food security for Californian growers. In contrast, the FAO report (2011) indicates ways in which biodiversity, through hedgerows, could contribute to sustainable food security. This report shows that agricultural biodiversity interventions need to encompass a variety of elements in an integrated way: inter- and intra-specific diversity of plants and animals, ecological interactions between wild, cultivated, above-ground, below-ground and aquatic species. The resulting eco-systemic services should not be seen as stand-alone elements, but as interacting actors in processes that ultimately support production and long-term food security.

All these approaches attempt to explain how biodiversity through the adoption of living hedgerows could contribute to food security, but do not economically assess the impact. This study attempts to fill this gap by identifying the socio-economic factors behind the adoption of living hedgerows and its impact on the food and nutritional security of rice-growing households in Côte d'Ivoire. The objectives of this study are:

- Determine the socio-economic factors behind the adoption of living hedgerows by small-scale rice growers in Côte d'Ivoire;
- Measure the impact of hedgerow adoption on the food and nutritional security of rice-growing households.

The stakes of this study lie in the fact that rainfed rice has been identified in the Nationally Determined Contributions CDN-CI (UNDP, 2022) as a major source of greenhouse gas emissions, and agroforestry appears to be a suitable and effective mitigation solution. Thus, the adoption of agroforestry practices by producers would be beneficial for the country.

2. THEORETICAL FRAMEWORK

2.1 The adoption of hedgerows

A farmer has adopted a technology if he uses that technology to some extent on his farm (Adams, 1982). Adams (1982) shows that adoption is generally the result of a series of influences exerted over time. For this reason, Agyemang (1991) views adoption as the behavior of individuals in relation to the use of technology, and in particular the reasons for adoption at a given point in time are of primary interest.

According to Morris and Adezina and Zinnah (1993), there is no single theory of causality that can encompass all aspects of adoption and explain the traditional attitudes of small-scale farmers in developing countries. However, this study adopts Tolman's (1967) model of adoption behaviour, which states that an individual's behaviour is a function of socio-economic and environmental factors, and that the goal of adoption is endogenous to the sum of the interacting forces in the individual's situation.

Tolman's (1967) theoretical model, taken up by Thangata (1996), shows that adoption behavior is governed by a set of intervening variables, such as individual needs, knowledge about the technology and individual perceptions of the methods used to meet these needs in a specific environment. However, these intervening variables depend on a range of factors such as the age of the household head, the size of the landholding, the level of awareness, contact with extension, income and the extent of the household's access to credit, among other variables (Mfungwe, 2012).

2.2 Food and nutritional security

Engler (2013) highlights four theories to explain food and nutrition insecurity: climatic theories, demographic theories, socio-economic theories and political theories. The climatic theory of food and nutrition insecurity was put forward by Cox (1981). Cox (1981) associated climate theory with the concept of the “famine belt”, in which he established a direct link between climatic conditions and food insecurity. According to this theory, at national or local level, climate-related phenomena such as drought, floods and the like are a major factor in food insecurity. However, this theory, which focuses solely on climatic aspects, is incomplete and deterministic. Why don't famines occur regularly in drought-stricken regions such as the Middle East or even parts of Spain (Devereux 1993)?

Demographic theories state that demographic factors are at the root of food insecurity and famine, because according to Malthus (1798), population growth will therefore exceed food availability, leading to famine or at least food insecurity due to overpopulation. However, this theory did not take into account the possibility of fundamental and profound improvements in agriculture, transport and communication within groups, communities or entire societies (Devereux 1993; Wisner et al. 2004). This limitation leads neo-Malthusians to consider the “ratio of population to arable land” as a formula for calculating the risk of food insecurity or famine (Devereux 1993), thus appealing to the concept of a biological species' carrying capacity.

Socio-economic theories of food insecurity take 3 main approaches to this subject: declining food availability, declining food entitlements and market failure approaches. The food availability approach is based on food supply and considers natural factors as the main cause of food insecurity and famine, and analyzes their influence on crop failures, price rises, etc. (Engler et al., 2014). The “declining food rights” approach focuses on the food rights of the population and considers the distribution of food to be far more important than its alleged availability (Sen, 1984). In this approach, Sen (1984) argues that access to food refers to issues such as wealth or poverty, being privileged or disadvantaged, being male or female, etc. However, Devereux (2001) characterizes the lack of interdisciplinarity as “a failure to recognize individuals as socially integrated members of households, communities and states, and secondly, a failure to recognize that famines are political crises as much as economic shocks or natural disasters. The market failure approach argues that food insecurity is due to the malfunctioning of markets in affected local areas, i.e. that markets do not meet the demand of the local population at the right time and in the right place (Devereux 1993).

Political theories of food insecurity take into account the factors of war, political mismanagement, political discrimination, fiscal policy in the food sector, corruption, poverty and social exclusion (Bose, 1990).

This study is based on the socio-economic theory of food insecurity, more specifically on the approach of declining food availability. This approach has the advantage of taking into account natural factors, such as agroforestry, soil conditions, etc., in the explanation of food insecurity.

3. METHODOLOGY

3.1 Sampling procedure and study data

The data for this study come from a survey conducted by the World Bank in 2021 as part of a project aimed at economically integrating small-scale rice producers into the value chain. Three regions were selected according to their importance in rice production: the Poro and Tchologo regions in the north of Côte d'Ivoire, and the Tonkpi region in the west of the country. In each region, 10 villages were selected and in each village 16 rice producers were selected using a stratified random sampling technique, where each village was considered as a stratum. A total of 480 farmers were interviewed. However, 23 producers were eliminated because they had not produced rice in the 2021 season, making a total of 456 producers. All these producers grow upland rice.

The questionnaire covered a number of topics, including producers' socio-economic characteristics, household composition, plot characteristics, agroforestry practices, food security issues and several other aspects of importance to the study.

Table 1 : Definition of study variables

Variables	Definitions
Age	In years (Continuous variable)
Years of study	Number of years of formal education (continuous variable)
Education	Binary variable (1= if the farmer has received training in the technical aspects of rice production, 0 otherwise)

Gender	Binary variable (1= male, 0 otherwise)
Employed	Number of assets owned by household (continuous variable)
Owner	Binary variable (1= if the producer owns the plot, 0 if not)
Household size	Number of people in household (continuous variable)
Distance	Distance in minutes between household residence and nearest town (continuous variable)
Farm size	Area of plots owned in ha (continuous variable)
Distance from plot	Distance in minutes between household residence and plot (continuous variable)
Clay soil	Soil type (binary variable, 1 if the soil is predominantly clay and 0 if not)
Lowland relief	Binary variable, (1 if the plot is a lowland and 0 if not)
Inclined slope	Binary variable (1 if the plot slope is steep and 0 if not)
Water source on plot	Binary variable (1 if the plot's main water source is rainwater and 0 if not)
Plot ownership	Binary variable (1 if the owner has a title deed and 0 if not)
Collective management of plot	Binary variable (1 if there is collective management of the plot and 0 if not)
Extension	Binary variable (1 if the producer has been visited by extension agents in the last 12 months and 0 if not)
Breeding	Binary variable (1 if the producer has animals and 0 if not)
Poro	1 if the producer is in the Poro region and 0 if not
Tchologo	1 if the producer is in the Tchologo region and 0 if not
Tonkpi	1 if the producer is in the Tonkpi region and 0 if not

Source : Author

3.2 Analysis methods

3.2.1 Measuring food security

The FAO (2009) defines food security as the situation in which "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". Thus, several measurement methods have been proposed in the literature (Bhalla et al., 2018; Smale et al., 2015). This study uses the Household Food Insecurity Experience Scale (HFIES) developed by the FAO to measure food security. This method has two main advantages. First, it is the first survey instrument to measure people's direct experiences of food insecurity at the individual level and is used globally (Smith et al., 2017). Secondly, we use the assumptions of the Rasch model to ensure the internal statistical validity of the data set (Cafiero et al., 2018). As part of the survey, household heads were asked whether they had experienced any of the following situations in the past 12 months due to a lack of money or other resources :

1) You were afraid you wouldn't have enough to eat.
2) You were unable to eat healthy, nutritious food.
3) You only ate a few different types of food.
4) You had to skip a meal.
5) You ate less than you thought you would.
6) Your household ran out of food.
7) You were hungry but didn't eat.
8) You went a whole day without eating.

Respondents are asked for a binary response, and each answer is assigned a score (yes=1 and no=0) as Cafiero et al., (2018) and Smith et al., (2017) have done. This gives us the original HFIES, which ranges from 0 to 8.

3.2.2 Estimation strategy

This study uses the propensity score matching (PSM) method to analyze empirical data (PSM). Since unmatched samples are more likely to be biased than matched samples, this method is preferred because of its ability to compare and predict impacts across incomparable samples and regions without similar or dissimilar participants (Kassie et al., 2010). Consequently, we use semi-parametric matching methods as an estimation technique to construct the counterfactual and mitigate the problems caused by selection bias. Thanks to this method, it is possible to identify plots where a living hedge is not practised (untreated), just as those where the living hedge is practised (treated) but with all the relevant observable characteristics. The difference lies in the fact that one group adopts hedgerows while the other does not.

In this method, propensity scores are first estimated for all plots. The average treatment effect for treated plots (ATT) can be estimated in the next step. Several techniques have been developed to match adopters with non-adopters who have comparable probability scores. In this study, we use Nearest Neighbor Matching (NNM), Radius Matching (RM), stratification and Kernel-based Matching (KM). The principle remains the same: numerically search for "neighbors" of untreated plots whose propensity score is very close to the propensity score of treated plots (Kassie et al., 2010; Caliendo and Kopeinig, 2008). To ensure that differences in covariates between the two groups in the matched sample are not significant, an equilibrium test is required after matching, in which case the matched comparison group can be considered a plausible counterfactual (Ali and Abdulai, 2010).

The propensity score matching technique begins by estimating a Probit model as follows:

$$P(X) = Pr(haie = 1|X) \tag{1}$$

Where P(X) is the conditional probability of receiving a treatment given the pre-treatment characteristics, hedge = {0, 1} is the indicator of whether or not to adopt live hedges, and X is the vector of pre-treatment characteristics. Estimation of this first equation provides the determinants of hedgerow adoption and enables us to achieve objective 1 of the study.

The average treatment effect on treated plots (ATT) is given by the following formula:

$$ATT = E[Y(1)|haie = 1] - E[Y(0)|haie = 1] \tag{2}$$

Where Y(1) represents the food security index of treated individuals and Y(0) that of control individuals. Thus, the determinants of hedgerow adoption are given by the first step of PSM, while the effects of adoption are determined by the second step.

4. RESULTS AND INTERPRETATION

4.1 Descriptive statistics

Table 2 summarizes the descriptive statistics of the variables used in the study. Observation of Table 2 reveals that there is a significant difference between the 2 groups with regard to the number of years of education of the head of household. On average, hedgerow adopters are better educated (2,262 years more) than non-adopters. This may highlight the need to understand the environmental benefits of biodiversity before adopting it. On average, farmers in the study area are male (0.941), have undergone 2,454 rice-growing training courses, have 7,410 members of their household and a farm area of 4,172 ha. Non-adopters have more assets and plot ownership status than adopters. This might suggest that non-adopters with a higher standard of living and plot ownership status do not find it useful to adopt living hedgerows to maximize their production.

Furthermore, adopters are on average further from the city than non-adopters. This could highlight the pressure of urbanization on biodiversity (Brice, 2015). On average, growers in the study area have lowland plots 29.114 minutes distant from their place of residence, having rainwater as their main water source. Adopters farm clay soils with shallower slopes to a much greater extent than non-adopters. This may suggest that plot selection plays a key role in hedgerow adoption. On average, growers in the study area have customary titles (62.9%), manage their plots individually (73.9%), are less involved in animal husbandry (19.5%) and have been visited less by extension agents (40.8%). The distribution of producers by region shows that the number of hedgerow adopters is higher in Tonkpi than in the other regions. This may be due to the region's rugged terrain.

Table 2: General differences between hedgerow adopters and non-adopters

Variables	All	Non-adopting	Adopting	Difference	P-value
Age	48.116	48.358	47.059	1.300	0.325
Years of study	2.454	2.033	4.294	-2.262	0.000
Education	2.125	2.159	1.977	0.183	0.655
Gender	0.941	0.944	0.929	0.014	0.623
Employed	765493.18	809784.078	572176.45	237607.63	0.056
Owner	0.737	0.766	0.612	0.154	0.004
Household size	7.410	7.477	7.117	0.359	0.402
Distance	28.480	27.059	34.685	-7.625	0.009
Farm size	4.172	4.229	3.928	0.300	0.704
Distance from plot	29.114	31.907	16.922	14.986	0.425
Clay soil	0.846	0.825	0.941	-0.117	0.007
Lowland relief	0.917	0.911	0.941	-0.030	0.366
Inclined slope	0.522	0.580	0.271	0.309	0.000
Water source on plot	0.768	0.752	0.836	-0.084	0.561
Plot ownership	0.629	0.636	0.600	0.036	0.535
Collective management of plot	0.261	0.262	0.259	0.003	0.961
Extension	0.408	0.420	0.353	0.068	0.254
Breeding	0.195	0.208	0.141	0.067	0.165
Poro	0.357	0.380	0.259	0.121	0.036
Tchologo	0.371	0.437	0.083	0.354	0.000
Tonkpi	0.272	0.184	0.659	-0.476	0.000
Observation	456	371	85		

Source : Author

4.2 Determinants of hedgerow adoption

Table 3 summarizes the results of the estimation of equation 1. It reveals that the number of years of formal education, rice training, distance from town, plot slope type, plot management method and geographical location of the household are the factors influencing the adoption of living hedges.

The number of years of study is positively related to the adoption of hedgerows. This result is in line with that of Lapar et al. (1999). In fact, agroforestry technologies including living hedgerows are considered knowledge-intensive technologies (Coulibaly et al., 2017). The level of education is therefore necessary to understand the scope of this practice. An alternative explanation is that education promotes the adoption of new agricultural technologies, such as living hedges (Paltasingh and Goyari, 2018). In the same vein, training in rice cultivation is positively linked to the adoption of living hedges. This result is in line with that of Coulibaly et al. (2017) who show, in the case of Malawian producers, that agroforestry training has a positive link with the adoption of agroforestry practices. In our study area, the rice training provided included a section on techniques for protecting rice crops from herders' livestock through agroforestry practices.

The distance between the grower's residence and the nearest town has a positive relationship with the adoption of live hedgerows. This result is contrary to those of Coulibaly et al. (2017) and Lapar et al. (1999), who show that distance has no significant effect on the adoption of living hedges. In our study area, this can be explained by the fact that villages far from the city are not under the pressure of urbanization and therefore have enough space for agroforestry practices. What's more, the distance from the city leads these producers to develop practices to protect and preserve the fertility of their plots, so as not to be dependent on products from the city.

The slope of the plot is negatively related to the adoption of hedgerows. This result is contrary to that of Lapar et al. (1999), who found that hedgerow adopters in the Philippine highlands had plots with steep slopes. In our study area, this could be induced by a lack of knowledge among growers regarding the benefits of hedgerows on steeply sloping soils exposed to the risk of erosion. Boinot and Alignier (2022) assert that hedgerows help combat soil erosion.

Collective plot management is positively linked to the adoption of hedgerows. This highlights the importance of the availability of manpower and knowledge in the management of plots and hedgerows. Indeed, collective plot management calls for the physical and intellectual contribution of all co-managers in the decision-making process for activities on the plot. It is therefore possible to accept proposals for agroforestry practices from co-managers who have already experimented with it.

Geographical location is positively linked to the adoption of living hedges. Growers in Tonkpi and Poro seem to adopt living hedges much more than those in Tchologo. However, the intensity of adoption is much higher in Tonkpi than in the other regions. This is undoubtedly due to the precautions producers take in the face of the risk of erosion demonstrated in the studies by Kouadio et al. (2007).

Table 3: Probit regression of hedgerow adoption determinants

Variables	Coefficient	Standart-Error	z	P-value

Age	0.053	0.061	0.860	0.388
Age2	-0.001	0.001	-1.080	0.282
Years of study	0.052	0.022	2.430	0.015
Education	0.045	0.026	1.700	0.090
Gender	0.111	0.376	0.300	0.767
Employed	-0.063	0.236	-0.270	0.791
Owner	-0.510	0.582	-0.880	0.381
Household size	-0.004	0.029	-0.130	0.893
Distance	0.162	0.079	2.060	0.039
Farm size	0.020	0.014	1.420	0.155
Distance from plot	-0.103	0.131	-0.780	0.433
Clay soil	0.126	0.337	0.370	0.709
Lowland relief	-0.416	0.350	-1.190	0.234
Inclined slope	-0.404	0.207	-1.960	0.051
Water source on plot	-0.029	0.091	-0.320	0.748
Plot ownership	0.731	0.534	1.370	0.171
Collective management of plot	0.767	0.244	3.140	0.002
Extension	0.005	0.208	0.020	0.982
Breeding	-0.075	0.285	-0.260	0.792
Poro	0.770	0.339	2.270	0.023
Tonkpi	1.868	0.346	5.400	0.000
Observation	456			

Source : Author

4.3 Impact of hedgerows on food and nutritional security

Table 4 summarizes the results of the impact of hedgerows on food and nutritional security. The average effect of the hedgerow adoption treatment on food security reveals a positive and significant effect, especially for the (NNM) and (RM) specifications, suggesting an improvement in the food security of adopting households. This result implies 2 important interpretations. Firstly, it would mean that when we consider plots with living hedgerows and plots without living hedgerows but which have the closest characteristics, living hedgerows significantly improve the food security of adopting households. Secondly, when considering plots within the radius of a given maximum propensity score, hedgerow adopters improved their food security relative to non-adopters. The improvement in food security due to the adoption of hedgerows ranged from 34% to 87%.

The average treatment effect of hedgerow adoption on nutritional security reveals a positive and significant impact, suggesting an improvement in the nutritional security of adopting households in the range of 2 points to 4 points.

These results are in line with those of Coulibaly et al. (2017), Long et al. (20217) and Karp et al. (2015). The latter provide a much more technical explanation of how hedgerows installed around plots contribute to food sovereignty by providing habitat for bees and other beneficial insects on farms.

Table 4: PSM results of hedgerow adoption on food and nutritional security

	Average treatment on treaties (ATT)			
Variables	Stratification method	Nearest Neighbor Matching method	Radius Matching method	Kernel Matching method
Food safety	0.741 (0.465)	0.741*(0.441)	0.869***(0.267)	0.346 (0.348)
Nutritional safety	2.647**(1.133)	2.647**(1.282)	3.683***(0.802)	2.088*(1.120)

Source : Author

5. CONCLUSION

Agroforestry is increasingly being recommended as a solution for mitigating the effects of climate change on farms. While the importance of agroforestry is undeniable, the economic impact of its many practices, such as live hedgerows, is not sufficiently documented in the literature. Living hedgerows contribute to soil conservation and are among the most stable refuges for biodiversity in agricultural landscapes, providing food and shelter for many living organisms. In this study, data from 456 small-scale rice farmers in the Poro, Tchologo and Tonkpi regions were used to analyze the impact of the adoption of living hedgerows on household food and nutritional security. The propensity score matching method was used to highlight the factors behind the adoption of living hedges and its impact.

Econometric results show that the adoption of living hedges plays a very important role in improving household food and nutritional security. To stimulate this adoption, the study recommends the use of training and awareness-raising. Training courses on the technical itinerary for rice production should incorporate agroforestry practices adapted to rice cultivation. In addition, awareness-raising sessions on the benefits of agroforestry, in particular the practice of living hedges, should be held in rural areas to arouse interest among producers. Extension agents from the Agence Nationale d'Appui au Développement Rural (ANADER) could be used for this purpose.

Notwithstanding the encouraging results of this study, there are certain limitations that should be taken into account in future studies. Firstly, there are methodological limitations linked to the inclusion of biophysical indicators that measure soil properties (Coulibaly et al., 2017) at plot level, which were not taken into account in this study. Secondly, some studies (Dunn et al., 2016) have shown that hedgerows present risks of pest multiplication that are harmful to cereal crops such as rice. It would therefore be necessary to investigate this phenomenon, its link with the practice of living hedges and its impact on agricultural production.

REFERENCES

Adams, M.E. (1982). Agricultural Extension in Developing Countries. London: Macmillan Press Ltd.

ADERIZ (2022). Rice production system in Ivory Coast. Report.

Adesina, A.A., & Zinnah, M.M. (1993). Technology characteristics, farmers perceptions and adoption decisions. A tobit model application in Sierra Leone Agricultural Economics, 9, 297-311

Agyemang, K.O. (1991). Socio Economic Cultural Issues in alley farming research and development. Paper prepared for the AFNETA Training Course for Eastern and Southern Africa English speaking countries. Nairobi, Kenya: KEFRI

Ali, A., & Abdulai, A. (2010). The adoption of genetically modified cotton and poverty reduction in Pakistan. Journal of Agricultural Economics, Vol. 61, pp. 175–192.

Bhalla, G., Handa, S., Angeles, G., & Seidenfeld, D. (2018). The effect of cash transfers and household vulnerability on food security in Zimbabwe. Food Policy, 74:82–99.

Bose, S. (1990). Starvation amidst plenty: the making of famine in Bengal, Honan and Tonkin, 1942-45. Modern Asian Studies, 24, 4, 699-727.

Brice, M.H. (2015). Impacts of urbanization on specific and functional diversity in riparian forests. University of Montreal, Master's thesis

.

Brodt S., Klonsky K., Jackson L., Brush S.B. & Smukler S. (2008). Factors affecting adoption of hedgerows and other biodiversity-enhancing features on farms in California, USA. Agroforest Syst (2009) 76:195–206 DOI 10.1007/s10457-008-9168-8.

Cafiero, C., Viviani, S., & Nord, M. (2018). Food security measurement in a global context: The food insecurity experience scale. Measurement, 116:146–152.

Caliendo, M., & Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. Journal of Economic Surveys, Vol. 22, pp. 31–72.

Cox, G. (1981). The ecology of famine: an overview. In J. Robson (Ed.), Famine: its causes, effects and management. New York: Gordon and Breach.

Devereux, S. (1993). Theories of famine. New York: Prentice-Hall.

Devereux, S. (2001). Sen’s Entitlement Approach: Critiques and Counter-critiques. Oxford Developmental Studies, 29(3), 245-263.

Dunn J. C., Gruar D., Stoate C., Szczur J., & Peach W. J. (2016). Can hedgerow management mitigate the impacts of predation on songbird nest survival?, Journal of Environmental Management, Volume 184, Part 3, 535-544, ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2016.10.028.

Engler, S. (2013). Food (in)security and famine – Understanding the interconnection of vulnerability, perception of affected populations, and their adaptation capacities in times of food scarcity. PhD thesis, Justus-Liebig-Universität Gießen.

Engler, S., Köster, J., & Siebert, A. (2014). Farmers Food Insecurity Monitoring : Identifying Situations of Food Insecurity and Famine. IFHV Working Paper Vol. 4 (3).

FAO (2009). Declaration of the world summit on food security: Food and Agriculture Organization of the United Nations. FAO, Rome.

Frison, E.A., Cherfas, J. & Hodgkin, T. 2011. Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. Sustainability, 3: 238–253

Kassie M., Zikhali P., Pender J., & Köhlin, G. (2010). The Economics of Sustainable Land Management Practices in the Ethiopian Highlands. Journal of Agricultural Economics, Vol. 61, No. 3, 605–627 doi: 10.1111/j.1477-9552.2010. 00263.x

Kouadio B.H., Kouamé K.F., Saley B.M., Biémi J., & Ibrahima T. (2007). Climate insecurity and geohazards in Côte d'Ivoire: study of the risk of water erosion of soils in the semi-mountainous region of Man (Western Côte d'Ivoire). Drought; 18 (1): 29-37

Lapar M.L.A., Pandey S., & Waibe H. (1999). Adoption of Contour Hedgerows by Upland Farmers in the Philippines: - An Economic Analysis. Discussion Paper, n°36, International Rice Research Institute (IRRI).

Levasseur V., Olivier A., & Franzel S. (2009). Factors of adoption of improved live fence in Mali. Cah Agric, vol. 18, n° 4.

Long, R. F., Garbach, K., & Morandin, L.A. (2022). Hedgerow benefits align with food production and sustainability goals. California Agriculture, Volume 71, Number 3. Doi: https://doi.org/10.3733/ ca.2017a0020

López-Felices, B., Aznar-Sánchez, J.A., & Velasco-Muñoz, J.F., Mesa-Vázquez E. (2017). Installation of hedgerows around greenhouses to encourage biological pest control: Farmers' perspectives from Southeast Spain. Journal of Environmental Management, Volume 323, https://doi.org/10.1016/j.jenvman.2022.116210

Malézieux, E. (2013). Editorial. Underutilized fruit trees in Africa. Numéro spécial. Revue Fruits (sous presse).

Malthus, T.R. (1798). An essay on the principle of population. Retieved from http://www.esp.org/ books/malthus/population/malthus.pdf

Mfungwe, L. B. (2012). Assessing the impact and adoption of agro-forestry food security programmes on the rural livelihoods: evidence from southern malawi. Master Thesis, University of Malawi.

Paltasingh, K.R. & Goyari, P. (2018). Impact of farmer education on farm productivity under varying technologies: case of paddy growers in India. Agricultural and Food Economics, 6, 7 https://doi.org/10.1186/s40100-018-0101-9

UNDP (2022). Nationally Determined Contributions (NDC-CI). Report

.

Sen, A. (1984). Resources, Values and Development. Oxford: Oxford University Press.

Smale, M., Mourad, M., & Ekin, B. (2015). How does adopting hybrid maize affect dietary diversity on family farms? Micro-evidence from Zambia. Food Policy, 52(1):44–53.

Smith, M. D., Rabbitt, M. P., & Coleman-Jensen, A. (2017). Who are the world's food insecure? new evidence from the Food and Agriculture Organization's food insecurity experience scale. World Development, 93:402–412.

Steffan-Dewenter, I., Kessler, M., Barkmann, J., Bos, M.M., Buchori, D., Erasmi, S., Faust, H., Gerold, G., Glenk, K., Gradstein, S.R., Guhardja, E., Harteveld, M., Hertel, D., Höhn, P., Kappas, M., Köhler, S., Leuschner, C., Maertens, M., Marggraf, R., MiggeKleian, S., Mogea, J., Pitopang, R., Schaefer, M., Schwarze, S., Sporn, S.G., Steingrebe, A., Tjitrosoedirdjo, S., Tjitrosoemito, S., Twele, A., Weber, R., Woltmann, L., Zeller, M. & Tscharntke, T. (2007). Tradeoffs between income, biodiversity, and ecosystem functioning during tropical rainforest conversion and agroforestry intensification. Proceedings of the National Academy of Sciences of the USA, 104: 4973–4978

Thangata, P. H. & Alavalapati, J.R.R. (1996). Resource poor farmers' perception of agro-forestry practices: A case study of Malawi. Unpublished Masters Thesis, University of Edinburgh, Scotland, UK.

Tolman, E. C. (1967). A psychological model. In: T. Parsons and E.A. Shils. Towards a general theory of action. Cambridge, MT: Harvard University Press.

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). At Risk. Natural hazards, people's vulnerability and disasters. Second Edition. London and New York: Routledge.