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Determinants of the Application of Economic Means to Recycle Yellow Corn Crop Wastes in Iraq

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ABSTRACT

This paper aims to study the impact of the determinants of applying economic means to recycle yellow corn crop residues in Iraq. Data were collected by designing a structured questionnaire from a sample of 300 yellow corn farmers in Babylon Governorate. The variable of the farmer's desire to recycle agricultural waste optimally was described as a dependent variable, while the independent variables are a set of socio-economic factors of the farmers in the research sample, including the age of the farmer, educational level, number of individuals, degree of knowledge of the existence of agricultural crop residues, degree of cultural openness, degree of willingness to participate in recycling agricultural waste, degree of willingness to bear risks for recycling waste, the availability of agricultural machinery and equipment related to recycling plant waste, agricultural experience, and area planted with the crop. The ordinal logistic regression model was used to analyze the study data, because the dependent variable is a qualitative variable that contains more than two categories and these categories are ordinal. The estimated results indicated that the willingness to optimally recycle maize waste in the study area is significantly affected by the age of the farmer, educational level, cultural openness, risk factor, availability of machinery, farmer experience, and farm area.

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KEYWORDS: Economic means, recycling, yellow corn wastes, ordinal logistic regression.

INTRODUCTION

The agricultural sector represents an important activity in most developing countries' economies, including Iraq, due to its absorption of more than a quarter of the total workforce, its contribution to the formation of the gross domestic product, and meeting food consumption needs, in addition to the production of goods and raw materials that are used as inputs in many manufacturing industries (Al-Saady and Al-Canany, 2018). The steady increases in population numbers and the increasing need to provide food in these countries have led to the adoption of policies based on agricultural intensification and crop diversity, in addition to the horizontal expansion of the agricultural area towards food manufacturing. The increase in agricultural productivity rates has resulted in a significant increase in plant and animal agricultural waste (Arab Organization for Agricultural Development, 2012), (Shaheed and Al badry, 2018). The environmental risks and damages of these wastes have become a matter of increasing concern regarding the disruption of the environmental balance and public health in the rural communities of these countries (Abdul Majeed and et al., 2017).

Accordingly, Iraq has recently shown increasing interest in the issue of agricultural waste and methods of using it in ways that are consistent with environmental requirements, as the scarcity of natural and economic resources used in agricultural production gives increasing economic and social importance and value to this waste, and necessitates the recycling of agricultural waste using optimal, technically developed, economically feasible and environmentally reconcilable methods, because the waste and neglect of agricultural waste entails significant economic burdens and environmental risks (Al-Salhi, 2020), (Arab Organization for Agricultural Development, 2012).

According to the United Nations Environment Programmer, the green economy plays an important role in improving human well-being and social justice, significantly reducing environmental risks, and enhancing the existence and sustainability of farm resources (FAO, 2016). The simplest forms of the green economy are characterized by reducing carbon dioxide emissions, reducing waste

and pollution, protecting the environment and biodiversity, improving resource efficiency, and integrating families into collective action (ILO, 2022), (Saddar and et al., 2024).

Agricultural waste is currently considered a heavy burden on the environment, especially since the improper disposal of this waste reflects wrong practices represented in wasting a valuable productive element available in the agricultural lands cultivated by farmers, and it may contribute to increasing soil fertility and entering into new and valuable industries if used properly (Aldoori and et al., 2016), (El-Gameel, 2019). Much of the agricultural production is characterized by the abundance of secondary products, most of which are agricultural waste. Some of these products have economic value, such as wheat and barley straws, bean and potatoes stalks, which are used as animal feed. Others are not useful from the farmer's viewpoint, such as rice straw, cotton and yellow corn stalks, most of which are summer crops. They have now become a heavy burden on the environment and on the farmer, who wants to get rid of them by any way (Fakhry and et al., 2017).

Agricultural waste recycling systems and methods vary to maximize their benefit according to the type of waste, available technology, and the purpose of recycling that waste. In general, the means of optimal exploitation are divided into (Abdul Wahab, 2015): 1) Biological methods: by harnessing microorganisms to convert organic agricultural waste into economically viable products, 2) Mechanical methods: to produce household, club, and industrial supplies, 3) Chemical methods: to produce paper and intermediate chemical compounds, 4) Physical methods: such as pressing, grinding, and maceration for ease of use, and others to produce hand-made products. Advances in biotechnology have led to the harnessing of microorganisms to convert organic compounds and wastes into economic products while preserving the environment from pollution, in addition to exploiting the ability of these microorganisms to produce food, feed, bioenergy, intermediate compounds, and purify wastewater, in addition to resisting the negative impact of these microbes to preserve human health and natural resources (Fakhry and et al., 2017), (Shaheed, and Al badry, 2018).

Although the yellow corn crop is one of the most important crops that are widely grown and that have a positive impact on food security in Iraq (Al-Hadethi, and Aftan, 2024), the large amount of agricultural waste that results from this crop after its harvest (stalks) and the failure to benefit from it leads to serious environmental, health and economic damage, in addition to the scarcity of state-owned and private sector machines that recycle this waste for later use, farmers are forced to dispose of it in wrong and environmentally harmful ways, as it is often disposed of by burning (Kadhim and et al., 2022). Given the economic importance of agricultural waste, which represents a waste of nutritional value on the one hand, and a waste of a product of great economic value and benefit, and a waste of energy in the event of its exploitation with an increase in the severity of environmental pollution resulting from this waste (Arab Organization for Agricultural Development, 2012). Therefore, the research problem appears by posing the following question: What are the determinants of applying economic methods for recycling agricultural plant waste in Iraq? The research aims primarily to determine the nature of the relationship between the willingness to use economic methods for recycling agricultural waste of maize crop, and the set of factors and variables affecting that use, in addition to identify the organizational, financial and training requirements necessary for the successful application of methods for the optimal exploitation of agricultural waste.

MATERIALS AND METHODS

Research Sample and Data

In order to achieve the research objective, a stratified random sample of 300 yellow corn farms in Babylon Governorate was selected. The field survey data included two types of yellow corn farmers (distributed across the various agricultural units of the governorate), namely farmers who apply economic methods in exploiting the agricultural waste of the crop, and farmers who do not apply optimal methods of exploitation in recycling the waste. It is noteworthy that Babylon Governorate ranks first among the Iraqi governorates that are famous for growing yellow corn in terms of area, production and productivity, where the area suitable for cultivation amounts to about 403 thousand hectares, constituting about 80% of the total area of the governorate (Alnagar and Kadhim, 2021). The area planted with yellow corn was estimated at about 13 thousand hectares in the 2024 agricultural season, and the total number of farmers reached about 9,620 farmers.

Study Variables

Based on previous studies (Fakhry and et al., 2017), (Kotb and Sadiq, 2010), (Mansour, 2017), (Porter, 2000), the variable of farmer's desire to recycle agricultural waste optimally was described as a dependent variable, while the independent variables are the socio-economic characteristics of the farmers in the research sample, including the age of the farmer, educational level, number of individuals, degree of knowledge of the existence of agricultural waste of the crop, degree of cultural openness, degree of willingness to participate in recycling agricultural waste, degree of willingness to tolerate risks for the sake of recycling waste, the availability of agricultural machinery and equipment related to recycling plant waste, agricultural experience, and area planted with the crop. All these variables are categorical variables, including quantitative variables (age, number of individuals, experience, and farm

area), which were converted into qualitative variables in line with the study objectives and the regression model used in the analysis. Table (1) shows all study variables, categories of each variable, and their coding systems.

Table 1. Study variables and their coding systems

No.	Variables	Categories	Code	No.	Variables	Categories	Code
1	Age	< 50 years ≥ 50 years	0 1	**6**	Degree of readiness to participate in recycling agricultural waste	Not willing to participate in reusing plant waste Low willingness to reuse plant waste High willingness to reuse plant waste	0 1 2
2	Educational level	Uneducated Reads and writes Primary stage Secondary stage Bachelor's degree and above	0 1 2 3 4	**7**	Degree of readiness to take risks for recycling waste	Not willing to recycle waste in the absence of available capabilities to reuse it, and to determine how to exploit it correctly Low willingness to recycle waste in the absence of available capabilities to reuse it, and to determine how to exploit it correctly High willingness to recycle waste in light of …….	0 1 2
3	Number of individuals	< 5 individuals 5-9 individuals ≥ 10 individuals	0 1 2	**8**	Availability of agricultural machinery and equipment related to recycling plant waste	Not available Available	0 1
4	Degree of knowledge about the presence of agricultural waste of the crop	Lack of knowledge Somewhat knowledge Good knowledge	0 1 2	**9**	Years of experience	< 30 years ≥ 30 years	0 1
5	Degree of cultural openness	Not following up on issues related to the field of agricultural waste Following up on local issues only Following up on local and global issues	0 1 2	**10**	Cultivated area	< 10 dunums 10 - 30 dunums > 30 dunums	0 1 2
6	**Dependent variable**				**Desire to optimally utilize and recycle agricultural waste**	**No desire** **Low desire** **Medium desire** **Strong desire**	**0** **1** **2** **3**

Source: Organized by researchers based on field survey data.

Study Model

To analyze the effect of different socio-economic characteristics of farmers on the desire to recycle agricultural waste optimally, the ordinal logistic regression model was used because the dependent variable is a categorical variable that contains more than two categories and these categories are ordinal (Gujarati and Porter, 2018). In other words, the values of each category have a meaningful sequential order, meaning that the dependent variable is in numerical form with specific values over a specific range of positive integers with reference to the possibility of there being one or more explanatory variables. Ordinal logistic regression does not place any conditions on the independent variables (Ibrahim, 2016). The study data were analyzed using the ready-made statistical program package SPSS.

RESULTS AND DISCUSSION

Results of the Survey on the Requirements for Applying Economic Exploitation Methods for Yellow Corn Waste in the Study Sample Farms

Table (2) shows the results of the survey of farmers' opinions regarding the requirements for applying the means of economic exploitation of agricultural waste in yellow corn farms. These requirements were represented in three basic groups, namely physical, organizational and training. Most of the sample farmers indicated the need to provide several financial requirements to maximize the benefit from agricultural waste, including providing financing at an appropriate interest rate to purchase crop waste recycling machines (90%), the need to provide chopping and cutting machines (82%), and working to provide spare tools and maintenance and upkeep workshops for waste recycling machines (80%). This necessitates meeting the requirements of these farmers, who confirm that there is a deficiency in terms of interest in them by the relevant official departments, which motivates them to make optimal and economic use of the agricultural waste remaining on the farm, in order to preserve their rural environment from pollution.

Regarding organizational needs, the sample farmers indicated, as shown in Table (2), the need to raise awareness of the importance of benefiting from agricultural waste and the effects of its misuse (77%). The sample farmers also stressed the need to establish agricultural cooperatives concerned with agricultural waste affairs and provide government support for them (72%). As for training requirements, the most important was training on the stages of non-traditional feed production (85%), followed in terms of importance by training on how to prepare, equip and turn fertilizer piles at (83%), then training skills on signs of fertilizer pile maturity and usage standards at (77%). These results require holding more training courses for farmers in the study sample, and working to provide them with training needs with a focus on practical demonstration methods to maximize the benefit from these courses.

Table 2. Relative importance of requirements for applying optimal utilization methods for yellow corn waste for the study sample

No.	Requirements	Items	Number of Farmers	Importance Percentage (%)
1	Physical	Providing places for recycling waste Supporting waste recycling machines and equipment Providing spare parts for these machines and equipment Providing workshops to maintain these machines and equipment Providing chopping and cutting machines Providing financing at an appropriate interest	90 140 240 240 246 270	%30 %47 %80 %80 %82 %90
2	Organizational	Providing the right place Establishing cooperatives for farmers Providing institutional support Raising awareness of the importance of utilizing waste and the effects of misuse	180 216 216 232	%60 %72 %72 %77
3	Training	Method of preparing fertilizer piles and preparing additives Stages of preparing non-traditional feed Method of using and maintaining chopping and cutting machines Method of preparing and turning fertilizer piles Signs of maturity of fertilizer piles and usage standards	250 256 210 250 232	%83 %85 %70 %83 %77

Source // Calculated by researchers based on field survey data.

Results of the Analysis of the Ordinal Logistic Regression Model for the Research Sample

Table (3) shows the results of the analysis of the ordinal logarithmic model, as the value of the chi-square for the model reached (657.745) with a probability of (0.000), which is highly statistically significant, indicating that the studied characteristics have a significant impact on the dependent factor (the desire to optimally exploit and recycle agricultural waste). The McFadden coefficient of determination (R^2), also known as pseudo, reached about (93%), indicating that the 93% fluctuation in the dependent factor is due to the characteristics and variables under study. In general, this value of the coefficient of determination must be avoided in the case of models in which the dependent variable is a qualitative or categorical variable. The estimated results in Table (3) show that there are three significant values for the constant of the intersection of the dependent variable with the y-axis due to the presence of four categories of the dependent variable under study, where these parameters or values can be used to calculate the expected probabilities for each category of the dependent variable for each farmer. It is also noted that there are seven explanatory variables that affect the phenomenon under study, and their significance was proven at different statistical levels.

The probability value of the farmer age variable was less than 0.05, and therefore its effect on the desire to optimally exploit and recycle agricultural waste was significant at the statistical level of 5%. The negative sign of the parameter of this variable means that young farmers (less than fifty years) are more likely to desire to optimally exploit and recycle agricultural waste compared to older farmers. The effect of the literacy category of the education level variable is significant at the 5% statistical level, while the effect of the primary level is significant at the 1% statistical level. The positive sign for each category of the education variable indicates that the probability of wanting to optimally exploit and recycle agricultural waste increases with the increase in the farmer's education level, and thus illiterate farmers are less willing to optimally exploit and recycle agricultural waste compared to educated farmers. The probability value of the cultural openness variable was about 0.009, which is less than 0.01, and thus the effect of this variable is significant at a very high statistical level. Similarly, the probability value of the risk tolerance variable and the availability of machines needed for the waste recycling process are also less than 0.01 (0.004, 0.000 respectively). Thus, their effect is also significant at a very high statistical level.

The effect of the number of years of experience is significant only for the first category (10%). This means that the farmer is likely to have a desire to optimally exploit and recycle agricultural waste if his experience in agriculture is less than (30) years. Finally, the farm area variable, as the probability value of this variable showed a very high statistical level (0.000) for two categories of farmers, namely farmers who have less than (10) dunums, and farmers who own between (10-30) dunums.

The negative sign of this variable parameter means that the probability of the desire to optimally exploit and recycle agricultural waste increases with the decrease in the size of the farm, and perhaps the reason for this is the lack of machines and equipment for recycling waste, as confirmed by many farmers in the sample, which would reduce the burden on the farmer no matter how large the farm size and the quantity of crop waste.

Table 3. Results of the analysis of the ordinal logistic regression model for the research sample

Parameter Estimates								
		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[dependent = .00]	-12.218	2.359	26.818	1	.000	-16.842	-7.594
	[dependent = 1.00]	-8.921	2.337	14.570	1	.000	-13.502	-4.340
	[dependent = 2.00]	-6.108	2.280	7.175	1	.007	-10.577	-1.639
Location	[age =.00]	-.459	.217	4.471	1	.034	-.884	-.033
	[age =1.00]	0[a]	.	.	0	.	.	.
	[edu=.00]	.948	.647	2.148	1	.143	-.320	2.215
	[edu=1.00]	.876	.407	4.641	1	.031	.079	1.674
	[edu =2.00]	.808	.327	6.101	1	.014	.167	1.449
	[edu =3.00]	.119	.226	.275	1	.600	-.324	.561
	[edu=4.00]	0[a]	.	.	0	.	.	.
	[individuals =.00]	-.490	.804	.372	1	.542	-2.065	1.085
	[individuals =1.00]	.166	.245	.458	1	.499	-.315	.647
	[individuals =2.00]	0[a]	.	.	0	.	.	.
	[knowledge =.00]	-.010	5.471	.000	1	.999	-10.734	10.714

	[knowledge =1.00]	-.350	.248	1.996	1	.158	-.835	.136
	[knowledge =2.00]	0[a]	.	.	0	.	.	.
	[openness =.00]	1.040	.400	6.770	1	.009	.256	1.823
	[openness =1.00]	.216	.312	.478	1	.489	-.396	.827
	[openness =2.00]	0[a]	.	.	0	.	.	.
	[readiness =.00]	-1.425	6.321	.051	1	.822	-13.814	10.964
	[readiness =1.00]	.341	.358	.908	1	.341	-.361	1.043
	[readiness =2.00]	0[a]	.	.	0	.	.	.
	[risk =1.00]	-.957	.336	8.109	1	.004	-1.616	-.298
	[risk =2.00]	0[a]	.	.	0	.	.	.
	[machines =.00]	-.978	.274	12.699	1	.000	-1.516	-.440
	[machines =1.00]	0[a]	.	.	0	.	.	.
	[experience =.00]	.452	.253	3.198	1	.074	-.043	.947
	[experience =1.00]	0[a]	.	.	0	.	.	.
	[area =.00]	-9.222	2.303	16.037	1	.000	-13.736	-4.709
	[area =1.00]	-8.813	2.296	14.740	1	.000	-13.312	-4.314
	[area =2.00]	0[a]	.	.	0	.	.	.

Link function: Complementary Log-log.

a. This parameter is set to zero because it is redundant.

Model Fitting Information					Pseudo R-Square	
Model	-2 Log Likelihood	Chi-Square	df	Sig.	Cox and Snell	0.888
Intercept Only	657.745				Nagelkerke	0.981
Final	.000	657.745	18	.000	McFadden	0.930

Source // SPSS output.

Based on the different values of the intercept constant of the estimated model, the expected probabilities for each level of the dependent variable were estimated assuming different values of farmers' characteristics, as shown in Table (4).

Table 4. Predicted probabilities for each level of the dependent variable assuming different values of farmers' characteristics

Number of Farmer	Farmer characteristics (explanatory factors)										Expected probabilities for the dependent variable categories (desire to optimally exploit and recycle agricultural waste)			
	Age	Edu.	Indiv.	Kno.	Open.	Rea.	Risk	Mach.	Expe.	Area	No desire (b0= -12.218 (	Low desire (b0= -8.921)	Medium desire (b0= -6.108)	Strong desire (base category) (b0= 0)
1	0	3	1	1	1	2	2	0	0	2	0.38901	0.389133	**0.39122**	0.389
2	0	3	1	2	1	2	2	0	0	2	0.73901	0.739133	**0.74122**	0.739
3	1	4	1	2	1	2	2	0	1	0	0.38201	0.382133	**0.38422**	0.382
4	0	3	1	1	1	2	2	0	0	0	0.38901	0.389133	**0.39122**	0.389
5	0	3	1	2	1	2	2	0	1	0	0.73901	0.739133	**0.74122**	0.739
300	1	3	1	1	0	2	2	0	1	2	0.17301	0.173133	**0.17522**	0.173

Source // Calculated by researchers based on field survey data and results of Table (3).

It is noted that the first case in Table (4) shows that the farmer is likely to have a medium desire to optimally exploit and recycle agricultural waste (highest expected probability = 39%) if he possesses the following characteristics, and so on for the rest of the farmers in the studied sample**:**
Age = 0 (less than 50 years).
Education level = 3 (secondary certificate).
Number of individuals = 1 (5-9 individuals).
Degree of knowledge = 1 (somewhat knowledgeable).
Cultural openness = 1 (following up on local issues only).
Degree of readiness to participate in recycling agricultural waste = 2 (high readiness).
Degree of risk tolerance for recycling waste = 2 (high tolerance).
Availability of machines = 0 (not available).
Years of experience = 0 (less than 30 years).
Farm area = 2 (more than 30 dunums).

CONCLUSIONS

The results of this paper indicated that there is a significant relationship between most of the determinants of applying economic means of recycling yellow corn crop waste and the desire to optimally exploit and recycle these wastes. The farmer's desire to optimally exploit and recycle his farm wastes is affected by several factors, including: the farmer's age, educational level, cultural openness, risk tolerance, availability of machinery, years of experience, and farm area. The high probability value of the chi-square test (0.000) for the estimated ordinal logistic regression model showed that there are significant combined effects of all the studied economic and social factors of farmers towards their desire to exploit and recycle agricultural waste. Accordingly, it can be concluded that there are determinants that strongly affect farmers' behavior towards the optimal exploitation of these wastes. Therefore, the characteristics of farmers must be taken into account when developing targeted plans and programs related to the exploitation and recycling of agricultural waste, with the necessity of holding practical courses on how to recycle agricultural waste optimally in the study area.

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