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Economic Valuation of Microbial Genetic Resources: The Case of Rhizobia Bio-fertilizer in Some Regions of Ethiopia

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Abstract: Economic valuation of microbial genetic resources was conducted in three Zones, Arsi from Oromia, East Shoa from Amhara and Wolhyta from Southern Nations Nationalities and People's Region (SNNPR) of Ethiopia. Willingness to pay (WTP) bids to use Rhizobia bio-fertilizer for production of different legumes was calculated. The average willingness to pay for bio-fertilizer in haricot bean production was 201.76 USD (at existing exchange rate) /household/ year. When bio-fertilizer was used for faba bean production, increase by 1 hectare of land, increased the willingness to pay for bio-fertilizer by 667 USD/quintal/year. Moreover, Higher income is significantly related to higher WTP at (F=72.17, sig. = 0.000). In general the study showed that those farmers who have gained benefits from using Rhizobia biofertilizers in all the studied Sub-districts (kebels) indicated highest WTP for the bio-fertilizers in the study. There were certain factors like size of land holding, yield per hectare and herbicides that affected the total yield and thereby the WTP. Although there might be other factors that contributed for yield increases of the leguminous plants in the studied area, it may be possible to conclude that the benefit from the use of the bio-fertilizer was significantly higher compared to those gains obtained without using bio-fertilizers. Despite that there has been certain controversy on methodological issues involving willingness-to-pay, the support of WTP in determining the economic value of genetic resources widely increased. Thus the current economic value estimate of the rhizobia bacteria may be indicated by the WTP of the studied farmers.

Keywords: Microorganism, Genetic Resources, Economic Valuation, Willingness to Pay, Rhizobia, Biofertilizer

1. Introduction

Microorganisms as components of biodiversity play important roles in different economic sectors including agriculture, pharmaceutical and in other industrial products. In Agriculture they are used as bio fertilizers and biological control agents. The biological nitrogen fixation by *Rhizobium* species and other bacteria are safe and cheap source of nitrogen fertilizer [1, 2]. Fertilizer nitrogen will continue to serve for increasing grain production until a foreseeable future, but effort are also being oriented towards augmenting biological nitrogen fixation mediated by microorganisms. Although microorganisms are valuable resources for present developments and future innovations there is no established method for determining the economic value of microbial resources collected from natural habitats. Therefore it is difficult to implement the Access and Benefit-sharing (ABS) principle of Convention on Biological Diversity (CBD). Masahiro [3] reports that the economic value of microbial resources used as screening material for developing new pharmaceuticals used to estimate the initial charge and expected royalties obtained from companies using the microbial genetic resources. Other than this report studies on economic valuation of microbial genetic resources are very scarce in the literature.

Bio fertilizers are the formulations of living microorganisms, which are able to fix atmospheric nitrogen in the available form to plants, either by living freely in the soil or being associated symbiotically with plants [4, 5] They are capable of mobilizing nutritive elements from non-usable form to usable form through biological processes. Biological nitrogen fixation (BNF) is carried out by both symbiotic and free living microorganisms. Nitrogen fixing bacteria are very selective in choosing roots of particular legumes species to infect, invade and form root nodules. *Rhizobium* has the exceptional ability to form nodules on roots or stems of leguminous plants. The Rhizobia living in the plant's root nodules carry out complex process by which the Rhizobia produce nitrogen for the legume is called biological nitrogen fixation, or BNF [6, 7].

In Ethiopia, legumes rank second as food after cereals and occupy about 15.2% of the total cultivated areas and contribute about 11.9% of the total production [8, 9]. Haricot bean and soybean are the two main lowland food legume crops. According to Bejiga, et al. [10] a ten year (2002 to 2012) soybean data showed that the land for production and total production increased by 10 and 21 fold, respectively; with average productivity of 1.06 ton ha-1 [8, 9].

Thus Rhizobia species in the process of biological nitrogen fixation for food and commercial legume production is very important. Therefore the present study attempts to estimate the economic value of Rhizobia strains used as bio fertilizer in areas where the highest distribution of the bio-fertilizers in three different legumes production.

The general objective of the study was to determine the economic value of *Rhizobium species* as Bio- fertilizer for production of leguminous crops.

Specific objectives

- To determine the Willingness to Pay (WTP) for *Rhizobium* Bio-fertilizer for the production of *Haricot bean*, Faba bean and Chickpea
- To determine factors affecting the value of *Rhizobium Bio- fertilizer* in the community.

2. Materials and Methods

2.1. Study Area

The study was conducted in three Zones, Arsi from Oromia; East Shoa from Amhara and Wolhyta from Southern Nations Nationalities and People's Region (SNNPR) of Ethiopia. The study was economic valuation of bio-fertilizer used for Faba bean, Haricot bean and Chick pea in Arsi, Wolayta, and East Shoa Zones respectively. Information on biofertilizer distribution was obtained from District (Woreda) Agricultural Offices of respective Zones. Accordingly, sub-districts (Kebeles) obtaining highest amounts of biofertilizer for each type of leguminous crops were selected. Two Kebeles, Bokoji negesso and Chibamickael from Limuna bilbilo district (Arsi), three Kebeles from Minjar Shonkore (Northern Shoa) and two Kebeles from Bolososore (Wolita Zone) were selected based on the highest consumption of rhizobial biofertilizer for production of Faba bean, Chick pea and Haricot bean respectively.

2.2. Sampling Techniques and Sample Size

Proportionate random sampling was used to draw respondents from the population of bio-fertilizer users in each sub-district (Kebele). Preliminary survey was conducted on 50 respondents before the actual study to identify the affecting factors and design study tool for the main study. The respondents involved in the study were interviewed by means of semi-structured questionnaire. Demographic and socio-economic information of respondents were recorded by interviewing each respondent in the respective area of the study.

2.3. WTP Bid Calculation and Model Specification

The individual willingness to pay (WTP) bids to use bio-fertilizer for production of different legumes was calculated using the equation previously used by Diwakar and Fred (11):

$$WTP= \Sigma(A_i\, Y_i\, P_i) - \Sigma(a_i\, y_i\, p_i) \quad (1)$$

Where WTP= total willingness to pay for bio-fertilizer, A_i= Area used for producing legume with bio-fertilizer, Y_i= yield of legume produced with bio-fertilizer, P_i= price of legume produced by using bio-fertilizer, a_i= area covered with legume without bio-fertilizer, y_i= yield of legume produced without using bio-fertilizer, P_i= price of legume produced without bio-fertilizer. Using this formula calculation was done for bio-fertilize in each of the three types of legumes cultivated in the specific study area. The WTP bids were transferred to SPSS statistical software (SPSS, version 21) for analysis. Mean willingness to pay, standard deviation, confidence interval and the relationship of WTP to categorical variables were analyzed using descriptive statistics, two sample t-tests and ANOVA. The WTP bids were also regressed with various explanatory variables. The bid functions were arrived at using linear regression analysis, starting from all the potential explanatory variables, removing the least significant one, re-estimating the model and so on until all remaining variables were significant at 95% level. The valuation function was adopted from Diwakar and Fred [11]:

$$WTP = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 ----\beta_nX_n + \beta_nX_n+e_n \quad (2)$$

WhereWTP = farmers willingness to pay for a specific legume for instance haricot bean's bio-fertilizer, β_0 = constant, β_1 - β_n = coefficients, X_1 - X_n = variables influencing WTP, e_n = random error

3. Result and Discussion

3.1. Demographic and Socio-economic

The demographic and socioeconomic data of respondents in all studied districts was recorded as part of the economic valuation questionnaire. Although the study design was to involve a total of 50 respondents, from each district, 10 respondents from Limuna bilbilo and 4 from Minjar Shonkore sub–districts did not appear during the interview. Thus, only a total 136 respondents were involved in the study.

The average age of respondents fall between 31-40 years (Table 1). The average size of a family was in the category 6-

10 persons (Table 1) while the national average is 4.6 [12]. The difference is significant at 95% confidence interval (F=4.85, sig. =0.000). This means the sampled respondent's family size is statistically significantly higher than the national average. From education point of view, the majority of respondents (63%) have primary education, the remaining include those unable to read and write as well as those at higher level education (Table 1)

Table 1. *Socio-demographic of the respondents selected for the study.*

Study Area	Geder		Age catagory			
	Male	Female	20-30	31-40	41-50	51 and above
Bolosore	50	0	16	17	15	2
Limuna bilbilo	39	1	4	21	9	6
MinJar Shonkore	44	2	0	18	14	14

Table 1. *Continued.*

Study Area	Level of Education				Family size		
	Unable to read &write	primary	secondary	College and above	1-5	6-10	11 and above
Bolosore	13	20	13	4	8	38	4
Limuna bilbilo	2	26	9	3	13	25	2
MinJar Shonkore	4	40	2	0	17	23	6

3.2. Willingness to Pay for Bio-fertilizer in Haricot Bean Production

The total willingness to pay for haricot bean's bio-fertilizer of 50 respondents is calculated using the formula below and shown in Table 2. The average willingness to pay is 201.76 USD (at existing exchange rate) /household/ year. The total willingness to pay is affected by some factors such as land holding, yield per hectare and herbicides. The yields of haricot bean by using bio-fertilizer and without bio-fertilizer are computed. The result shows the average yield of haricot bean is 1017 kg when using bio-fertilizer, and 365 Kg without using it. There is a difference of 652 kg. Yield and WTP are positively correlated with each other (Fig. 1). As the mean yield of haricot bean with bio-fertilizer exceeds by 652 kg the difference is significant (t=8.5, sig.= 0.000) at 95% level).

Table 2. *Willing ness to pay for biofertilizer in haricot bean production.*

TP with bio-fertilizer (A_i Y_i P_i)			WTP without bio-fertilizer (a_i y_i p_i)			WTP with bio-fertilizer USD	WTP without bio-fertilizer USD	Total willingness to pay WTP= $\Sigma(A_i Y_i P_i) - \Sigma(a_i y_i p_i)$ USD
Area	Yield	Price (USD)	Area	Yield	Price (USD)			
.80	21	22.7	.75	10	18.2	381.8	136.4	257
.50	9	31.8	.50	2	13	143.2	13	135.7
.25	13	31.8	.27	5	22.7	103.4	30.7	76..2
.50	10	27.3	.25	1	9.1	136.4	2.7	140
.25	12	27.3	.25	4	22.7	81.8	22.7	61.9
.25	7	27.3	.25	3	25	47.7	18.8	30.4
.50	7	31.8	.25	3	13	111.4	10.2	106
.25	7	31.8	.25	3	18	55.9	13.6	44
.25	7	36.4	.25	3	27.3	63.6	20.5	45.2
.25	10	36.4	.25	3	27.3	90.9	20.5	73.8
.25	7	31.8	.25	3	18	55.9	13.6	44
.25	7	27.3	.25	2	9.1	47.7	4.5	45.2
.25	12	34.1	.25	4	22	102.3	22.7	83.3
.50	10	27.3	2.00	3	27.3	136.4	163.6	28.6
.50	8	22	.50	2	13	90.9	13.6	80.9
1.00	4	29.5	.25	1	18	118.2	2.7	121.4.
.25	7	30.9	.25	4	22	54.1	22.7	32.9
.75	12	31.8	.50	1	9.1	286.4	4.5	295.2.
.50	8	31.8	.50	5	22	127.3	56.8	73.8
1.00	4	31.8	.50	3	29.5	127.3	36.9	94.6.
.25	5	18	.25	3	13	22.7	10.2	13.1.
.25	10	27.3	.25	4	18	68.2	18.2	52.4

TP with bio-fertilizer (A_i Y_i P_i)			WTP without bio-fertilizer (a_i y_i p_i)			WTP with bio-fertilizer USD	WTP without bio-fertilizer USD	Total willingness to pay WTP= $\Sigma(A_i Y_i P_i) - \Sigma(a_i y_i p_i)$ USD
Area	Yield	Price (USD)	Area	Yield	Price (USD)			
.40	12	27.3	.25	4	22	139.9	22.7	113.3
.50	5	29.5	.50	3	22	73.9	34	41.7
.25	4	28.2	.25	2	25	24.7	12.5	12.7
.50	12	29.1	.25	6	24.1	174.5	36.1	145
1.00	25	31.8	.50	10	9.1	795.5	45	785.7
.25	9	40.9	.25	3	20.5	86.9	15.3	75
1.00	18	45.5	1.00	5	31.8	81.8	159.1	690.5
.40	16	31.8	.25	5	22	203.6	28.4	183.6.
2.00	7	27.3	.50	4	22	381.8	45	352.4
1.00	17	27.3	1.00	7	18	463.6	127	352.4
.50	7	40.9	.25	3	18	143.2	13.6	135.7
.50	10	27.3	1.00	6	18	136.4	109.1	28.6
.25	7	40.9	.50	2	13	71.6	13.6	60.7
2.00	6	25	.25	2	18	300	9.1	304.8
1.00	3	13	.25	4	11.4	40.9	11.4	31
1.50	8	21.8	.25	1	22	245.5	5.7	251.2
2.00	6	20.9	.25	1	13.6	251.1	3.4	259.3
.50	9	22	.25	1	9.1	102.3	2.7	104.8
.50	4	22	.13	3	18	45	5.7	41.7
2.00	20	27.3	2.00	4	18	1090.9	152.4	990.5
1.00	10	27.3	1.00	7	18	272.7	127	152.4
.50	18	27.3	.50	9	13	238.6	59.1	185.7
.25	6	22	.25	2	13	34.1	6.8	28.6
1.00	4	20.5	.25	2	21.8	71.6	10.9	63.6
2.00	10	27.3	.50	4	13	545.5	22.3	542
3.00	14	27.3	.75	4	6.8	1145.5	17.9	1181.3
.25	12	54.5	.25	8	36.4	163.6	72.7	95.2
1.00	35	27.3	.25	1	9.1	954.5	1.1	998.8.

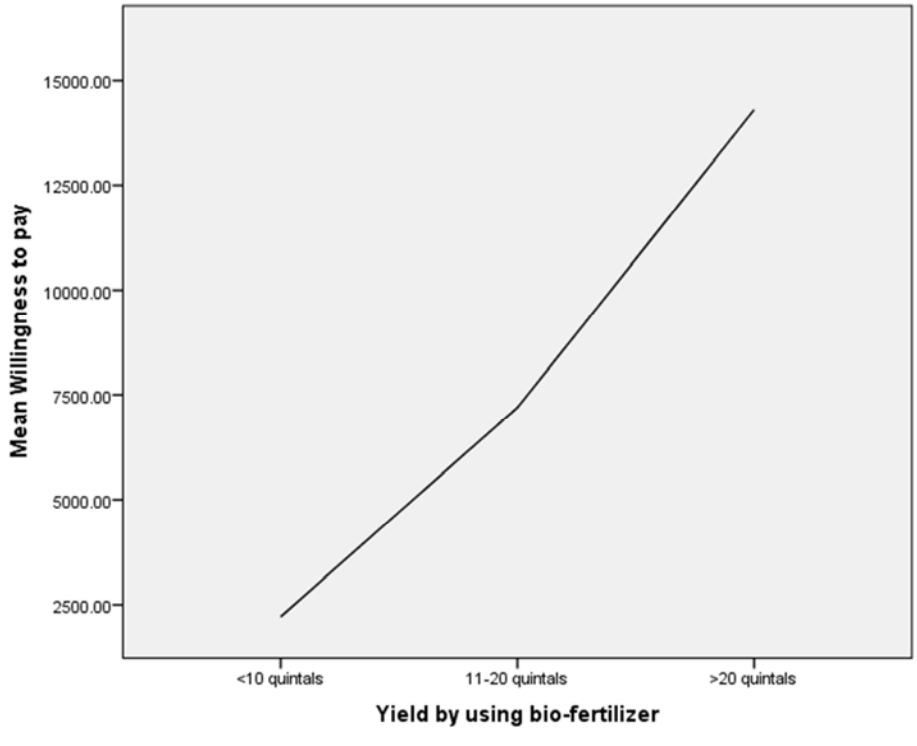

Fig. 1. *The relationship between haricot bean's yield and WTP (Birr= local currency exchange rate 1USD=22Birr).*

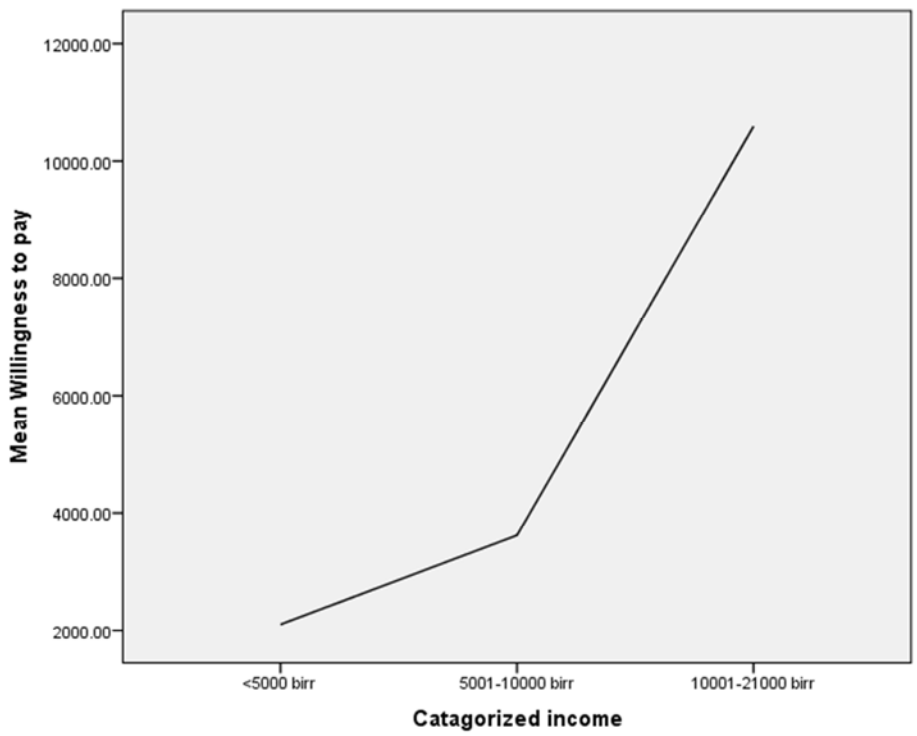

Fig. 2. *Mean willingness to pay vs income of haricot bean (Birr= local currency exchange rate 1USD=22Birr).*

3.3. Willingness to Pay (WTP) for Bio-fertilizer in Faba Bean

Table 3 and Figure 2 shows WTP, When bio-fertilizer was used for Faba bean production, increase by 1 hectare of land, increases the willingness to pay for bio-fertilizer by 667 USD/quintal/year. More over Higher income is significantly related to higher WTP at (F=72.17, sig. = 0.000). There is strong correlation between the explanatory variables and WTP (R = 0.79. R^2 = 0.62). Yield increase of Faba bean by using bio-fertilizer has been also reported by other study from Ethiopia [13]. The same study reported several benefits of biofertilizer including increased size and plumpness of Faba bean seeds resulting in higher sale prices; increased soil fertility – more organic matter as plants are harvested at ground-level leaving roots and nodules in the soil – supporting a transition away from fallowing and supporting an increase in productive farm holding size; reduced use of fertilizer.

Table 3. *WTP for Faba bean in respondents of Lemuna bilbilu Woreda (Arsi).*

WTP with bio-fertilizer (A_i Y_i P_i)			WTP without bio-fertilizer (a_i y_i p_i)			WTP with bio-fertilizer (USD)	WTP without bio-fertilizer (USD)	Total willingness to pay (WTP)= $\Sigma(A_i Y_i P_i) - \Sigma(a_i y_i p_i)$ USD
Area	Yield	Price (USD)	Area	Yield	Price (USD)			
.25	5	33.3	.25	3	19.05	41.66	14.29	27.38
.25	6	33.3	.25	3	19.05	50	14.29	35.71
.25	5	71.43	.50	8	52.38	89.29	209.52	-120.24
.75	25	80.95	.25	6	38.09	1517.86	57.14	1460.71
.75	18	57.14	.50	8	42.86	60	171.43	60
.25	6	80.95	.25	5	41.90	121.43	52.38	69.04
.38	12	80.95	.25	7	57.14	364.29	100	264.29
.25	8	38.09	.25	5	33.33	76.19	41.66	34.52
.25	5	61.90	.25	3	42.86	77.38	32.14	45.24
.25	7	61.90	.25	4	33.33	108.33	33.33	75
.38	10	47.62	.25	9	42.86	180.95	96.43	84.52
.25	3	57.14	.13	3	52.38	42.95	20.43	22.49
.25	5	61.90	.25	4	42.86	77.38	42.86	34.52
.50	12	38.09	.50	6	33.33	228.57	100	128.57
.38	9	57.14	.25	5	33.33	195.43	41.66	153.76
.50	13	61.90	.25	5	33.33	402.38	41.66	360.71
.25	9	57.14	.25	7	33.33	128.57	58.33	70.24

WTP with bio-fertilizer (A_i Y_i P_i)			WTP without bio-fertilizer (a_i y_i p_i)			WTP with bio-fertilizer (USD)	WTP without bio-fertilizer (USD)	Total willingness to pay (WTP)= $\Sigma(A_i Y_i P_i) - \Sigma(a_i y_i p_i)$ USD
Area	Yield	Price (USD)	Area	Yield	Price (USD)			
.25	8	57.14	.25	4	42.86	114.29	42.86	71.43
.25	8	40.48	.25	4	35.71	80.95	35.71	42.86
.25	7	71.43	.25	3	38.09	125	28.57	96.43
1.00	32	71.43	.50	11	33.33	2285.71	183.33	2102.38
.25	7	38.09	.25	5	23.81	66.66	29.76	36.90
.25	7	33.3	.25	5	23.81	58.33	29.76	28.57
.75	17	61.90	1.00	10	47.62	789.29	476.19	313.10
.25	7	38.09	.25	1	23.81	66.66	5.95	60.71
.25	5	52.38	.25	2	33.33	65.48	16.66	48.81
.25	6	57.14	.25	4	33.33	85.71	33.3	52.38
.25	6	57.14	.25	5	38.09	85.71	47.62	38.09
.25	6	38.09	.25	4	28.57	57.14	28.57	28.57
.25	7	42.86	.25	7	33.33	75	58.33	16.66
.50	24	47.62	.50	16	38.09	57.14	304.76	266.66
.50	15	78.58	.50	16	38.09	589.29	304.76	284.52
.50	37	71.43	.50	25	38.09	1321.43	476.19	845.24
.25	8	71.43	.25	3	38.09	142.86	28.57	114.29
.25	4	33.3	.25	4	28.57	33.3	28.57	4.56
.38	14	66.66	.25	6	38.09	354.66	57.14	297.52
1.00	29	76.19	1.00	20	47.62	2209.52	952.38	1257.14
.50	4	42.86	.50	12	38.09	85.71	228.57	14.29
1.00	5	76.19	.50	6	38.09	380.95	114.29	266.66
.25	6	52.38	.25	4	42.86	78.71	42.86	35.71

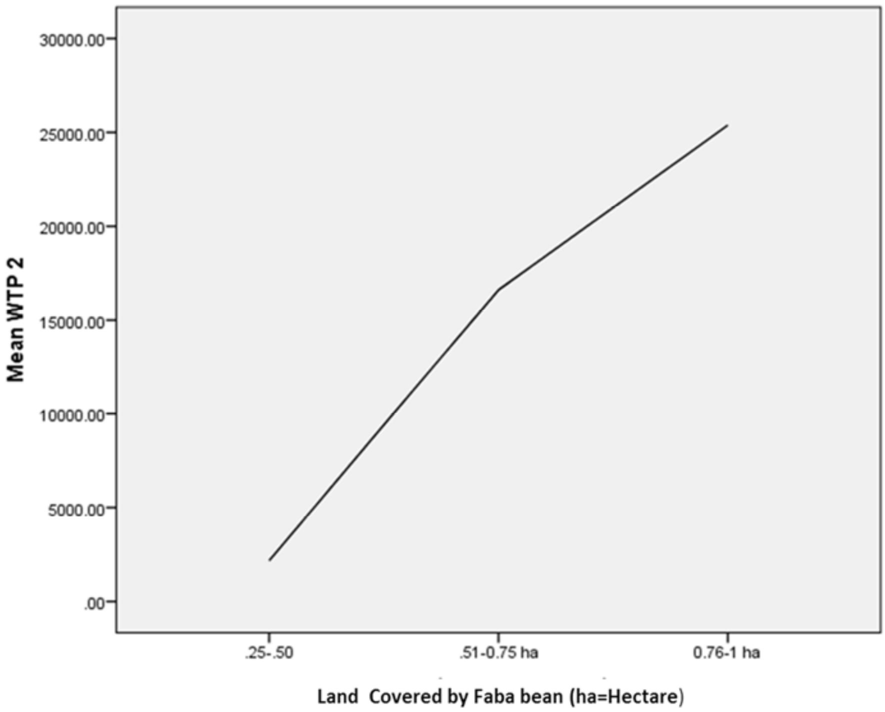

Fig. 3. *The relationship between hectare of land covered by Faba bean bio-fertilizer and WTP.*

3.4. Willingness to Pay (WTP) for Bio-fertilizer in Chick Pea

Fig. 3 shows the mean willingness to pay versus hectare covered by bio-fertilizer for Chickpea. When hectare covered by Chickpea bio-fertilizer increases, the willingness to pay for bio-fertilizer increases. They use higher hectare of land when they saw with bio-fertilizer than any other fertilizer. As the yield of Chickpea with bio-fertilizer increases by one quintal, the WTP for bio-fertilizer also increases. A previous study in the same zone, East Shewa [13]also observed substantial increases in Chickpea yields in two *kebeles* studied after the use of bio-fertilizer, but the same report indicated little or no yield increases in another kebele and that was attributed to poor quality seed, and erratic and poor rains.

The independent sample t-test proves that there is significant difference in WTP with difference in hectare of land covered by Chick pea bio-fertilizer by Levene's Test at (F=28.78, sig.= 0.000). From this it may be concluded that the use of bio-fertilizer significantly affect WTP. Farmers who cover large area of their land with Chick pea bio-fertilizer have higher WTP than others.

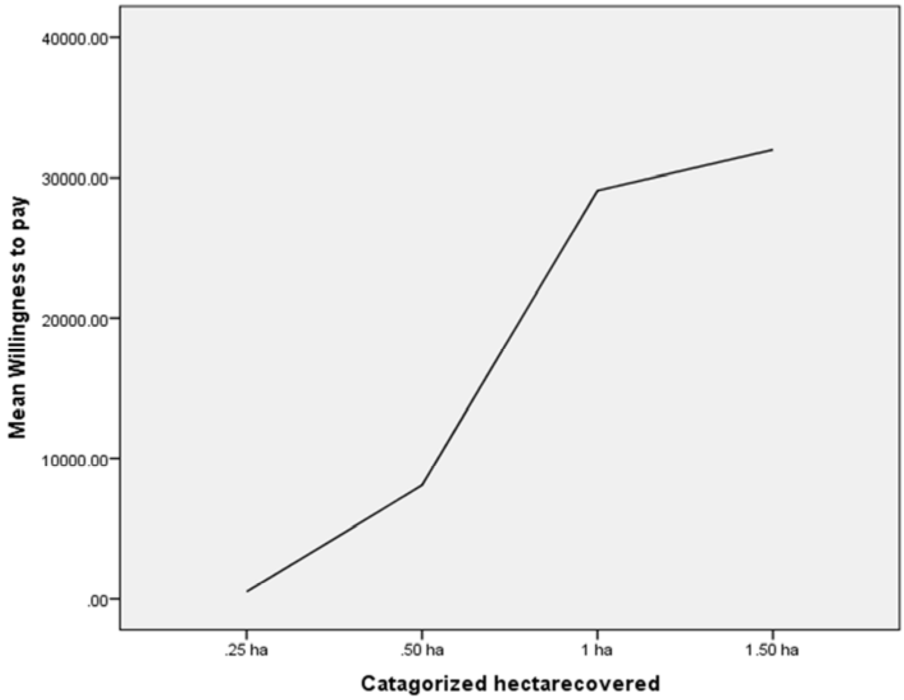

Fig. 4. *The relationship between hectare of land covered by Chick pea bio-fertilizer and WTP.*

Table 4. *WTP for chick pea of respondents in Minjar woreda (East Shoa).*

WTP with bio-fertilizer (A_i Y_i P_i)			WTP without bio-fertilizer (a_i y_i p_i) (USD)			WTP with bio-fertilizer (USD)	WTP without bio-fertilizer (USD)	Total willingness to pay WTP = $\Sigma(A_i Y_i P_i) - \Sigma(a_i y_i p_i)$ (USD)
Area	Yield	Price (USD)	Area	Yield	Price			
.25	10	66.66	.13	3	42.86	166.66	13.39	153.27
.25	12	76.19	.38	16	42.86	171.43	257.14	-85.71
.25	12	76.19	.25	9	38.10	171.43	85.71	85.71
.25	12	42.86	.25	7	52.38	171.43	91.66	79.76
.25	7	42.86	.25	6	38.10	108.33	72	36.31
.25	7	76.19	.50	2	19.04	116.66	19.05	97.62
.25	7	33.33	.13	5	19.04	100	11.90	88.10
.25	9	42.86	.25	6	42.86	150	64.29	85.71
.25	9	76.19	.25	6	71.43	139.29	107.14	32.14
.25	7	57.14	.25	6	38.10	125	57.14	67.86
.25	11	76.19	.50	16	45.24	196.43	361.90	-165.48
.25	9	57.14	.25	8	57.14	171.43	114.29	57.14
.50	14	47.62	.25	4	38.10	400	38.10	361.90
.25	15	28.57	.25	11	47.62	403.57	130.95	101.19
.50	17	28.57	.75	12	42.86	607.14	385.71	221.43
.25	7	76.19	.50	6	42.86	133.33	128.57	4.76
.25	9	75.24	.25	7	47.62	117.86	77.38	40.48
.25	11	66.66	.25	9	33.33	117.86	75	42.86
.25	6	71.43	.25	4	28.57	64.29	28.57	35.71
.25	10	80.95	.25	7	23.81	101.19	41.66	59.52
.25	7	61.90	.50	4	38.10	133.33	76.19	57.14

WTP with bio-fertilizer ($A_i Y_i P_i$)			**WTP without bio-fertilizer ($a_i y_i p_i$) (USD)**			**WTP with bio-fertilizer (USD)**	**WTP without bio-fertilizer (USD)**	**Total willingness to pay WTP = $\Sigma(A_i Y_i P_i) - \Sigma(a_i y_i p_i)$ (USD)**
Area	**Yield**	**Price (USD)**	**Area**	**Yield**	**Price**			
.25	12	59.52	.25	6	30.95	121.43	46.23	75
.25	6	66.66	.25	8	33.33	114.29	28.57	85.71
.50	16	76.19	.25	5	57.14	609.52	71.43	538.10
.50	20	76.19	.25	4	38.10	66.66	38.10	628.58
.25	14	42.86	.25	4	47.62	266.66	47.62	219.05
.25	9	42.86	.25	6	33.33	171.43	50	121.43
.25	15	76.19	.50	4	33.33	160.71	66.66	94.05
.50	15	33.33	.50	6	33.33	321.43	100	221.43
.25	3	42.86	.25	10	57.14	57.14	142.86	-85.71
.50	12	76.19	.25	3	28.57	200	21.43	178.57
.25	6	57.14	.25	5	28.57	64.29	35.71	28.57
.50	5	76.19	.50	4	71.43	190.48	142.86	47.62
.25	7	57.14	1.00	16	42.86	100	685.21	585.71
.25	3	47.62	.25	8	33.33	57.14	66.66	-9.52
.50	21	28.57	.75	12	42.86	600	385.71	214.29
.25	7	28.57	.25	4	76.19	83.33	76.19	7.14
.25	9	76.19	.25	4	19.04	64.29	19.05	45.24
.25	9	75.24	.50	6	33.33	64.29	100	35.71
.25	9	66.66	.50	7	42.86	171.43	150	21.43
.50	20	71.43	.25	7	38.10	752.38	66.66	685.71
1.00	24	71.43	1.00	5	42.86	1600	214.29	1381.71
.50	24	61.90	.25	8	52.38	857.14	104.76	752.38
.25	6	59.52	.50	8	42.86	121.43	171.43	-50
1.50	23	66.66	.75	10	42.86	2135.71	321.43	1814.29
1.50	14	76.19	.13	5	28.57	1250	18.57	1231.43

4. Conclusion

Establishing the economic value of microorganisms for supporting the implementation of the Nagoya Protocol of Access and Benefit sharing is very difficult as there is no established method for evaluating the economic value of microbial resources collected from natural habitats [3]. Therefore the benefit–sharing agreement on microbial resources in the context of implementing the Access and Benefit sharing is very difficult to conclude. Some studies estimated the economic value of ex-situ microbial resources based on microbial resources used for screening materials for developing new pharmaceuticals. Rhizobial biofertilizers are the formulations of living microorganisms, which are able to fix atmospheric nitrogen in the available form to plants, being associated symbiotically with plants (4, 5, 6). Market price does not reflect the real value of genetic resources even if these enter into the market because there is market failure to realize the benefits contributed. On the other hand economic value considers additional benefits than that (demand and supply principle, etc.) which determine price in the market. The current study attempts to estimate the economic value of Rhizobial biofertilizers used by farmers of Haricot bean, Faba bean and Chick pea. The study does not attempt to determine the economic value of Rhizobium species directly but the willingness to pay by the farmers using Rhizobia bio-fertilizers for producing the legumes. It can be understood that the farmers Willingness to pay for biofertilizer is because of the benefit they gain from extra yield since the willingness to pay increases with increasing yields, the relationship is direct and significant. Higher income is related to higher yield. Thus the difference in income from using the bio fertilizer may be considered as the economic value estimate for the microbial bio fertilizer used in the study conditions. In general the study showed that those farmers who have gained benefits from using biofertilizers in all the studied kebels indicated highest WTP for the biofertilizers in the study. There were certain factors like size of land holding, yield per hectare and herbicides that affected the total yield and thereby the WTP. Although there might be other factors that contributed for yield increases of the leguminous plants in the studied area, it may be possible to conclude that the benefit from the use of the bio-fertilizer was significantly higher compared to those gains obtained without using biofertilizers. Despite that there has been certain controversy on methodological issues involving willingness-to-pay, the support of WTP in determining the economic value of genetic resources widely increased. Thus the current economic value estimate of the rhizobial bacteria may be indicated by the WTP of the studied farmers.

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References

[1] Edward, S., Demissie, A., Bekele, T. and Haase, G. (1999). Forest genetic resources conservation: Principles, strategies and actions, Proceedings of the national forest genetic resources conservation strategy development workshop, January 21-22, 1999, Addis Ababa Ethiopia.

[2] Wooyoung, C., Doohyun B. and Hong, S. (*2008)*. Economic valuation methods of biodiversity. *Environ. Eng. Res.* 13: 41-48. 13.

[3] Masahiro M. [2006]. Economic value of Microbial resources. *Microbial Cult. Coll*. Pp: 15-19.

[4] Secretariat of the convention on biodiversity (1992). Convention on Biodiversity. 5 July, 1992, Rio Dejenero.

[5] Mmbaga, G. W., Mtei, K. M, Ndakidemi, P. A. (2014). Extrapolations on the use of *Rhizobium i*noculants supplemented with phosphorus (P) and potassium (K) on growth and nutrition of legumes. *Agricultural Sciences*, 5: 1207-1226.

[6] Chianu, J. N., Huising, J., Danso, S., Okoth, P. and Sanginga, N. (2010). Financial Value of Nitrogen Fixation in Soybean in Africa: Increasing Benefits for Smallholder Farmers. *Journal of Life Sciences*, 4: 934-7.

[7] World federation for culture collection (WFCC) (1998). The economic value of microbial genetic resources: paper presented at the eighth international symposium on Microbial Ecology. Halifax, Canada.

[8] Desmeth, P., Kurtböke, I. and Smith, D (2009). Tools to implement the Nagoya Protocol on Access and benefit sharing (ABS) in microbiology. An intrinsic preoccupation of the WFCC http://www.wfcc.info.

[9] Shiferaw, B., Jones, R., Silim, S., Teklewold, H. and Gwata, E. (2007). Analysis of production costs, market opportunities and competitiveness of Desi and Kabuli chickpeas in Ethiopia. IPMS Working Paper 3. ILRI, Addis Ababa, Ethiopia. Pp: 1-48.

[10] Bejiga, G., Eshetu, M. and, Anbese, Y. (1996). Improved cultivars and production technology of chickpea in Ethiopia. Research Bulletin No. 2. Debre-Zeit, Ethiopia: Debre- Zeit Agricultural Research Center, Alemaya University of Agriculture. P, 60.

[11] Diwakar, P. and Fred, J. (2009). Valuation of Crop genetic resources in Kaski, Nepal: Farmers Willingness to Pay for Rice Land Races Conservation, *J. Environ Mangt.* 90: 483-91.

[12] CSA (2015). Agriculture Sample Surveys www.csa.gov.et/index.php/about-us/8-home

[13] Agricultural Knowledge Learing Documentation and Policy Project (AKLDP) (2016). Improving Crop Yields in Ethiopia: Early Impacts from Rhizobia inoculated legume seed.. *Technical Brief Feb 2016.*