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Factors affecting the adoption of biofertilizers in Chitwan District, Nepal

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Abstract
This study was conducted in 2018 to analyze the factors affecting the adoption of biofertilizers in Chitwan district of Nepal. Chitwan district was selected for this study as it was one of the major commercial farming region of Nepal. The study area was divided into six clusters (Rapti, Kalika, Khairehani, Ratnanagar, Bharatpur, and Madi). Simple random sampling technique was used to select the 200 samples from clusters. Semi structured interview schedule was used to collect the primary information from sampled households whereas key informant interview was used to collect the information from the stakeholders. Adoption of biofertilizers was used as dependent variable and age, gender, education, primary occupation, farming experience, farm income, farm size, training and memberships in organization of respondent were used as independent variables. Forward LR method in Binary logistic regression model have shown primary occupation, farm size and training had significant effect on adoption of biofertilizer. About 40% of farmers were found to apply the biofertilizers. Knowledge gap in farmers about the use of biofertilizers and tradition of using chemical fertilizers were found to be the prime factors for lack of adoption of biofertilizers in Chitwan.

Keywords: Biofertilizers, adoption, factors, knowledge gap

1. Introduction
The increasing population is creating the considerable pressure on land and other natural resources causing serious impacts on agriculture ecosystem. There is great challenge to increase the level of production from the limited agricultural lands. Nepalese economy is based on agriculture and at present65.6% of total population is engaged in agriculture for their survival and economic benefit (MoAD, 2014). For agriculture, major source of nutrients is given through either farm yard manure or inorganic fertilizers. It is estimated that the world demand for total fertilizer nutrients (Nitrogen, Phosphorous, and Potash) will increase by 1.8 percent per annum from 2014 to 2018(FAO, 2015). Worldwide, the consumption of fertilizers is largest in East Asia followed up by South Asia (FAO, 2015). In Nepal, annual sales of chemical fertilizerswere 232189 Mt. (Urea 145622 Mt,DAP 81520 Mt and Potash 5046 Mt.). Among these, 8861 Mt. (Urea 5679 Mt, DAP 2645 Mt and Potash 537 Mt) were consumed in Chitwan district (MoAD, 2014).In Nepal, availability and affordability of inorganic fertilizers at farm level have been ensured only through imports and subsidies (Shrestha, 2010). The massive use of chemical fertilizers has adverse effect on crop productivity, soil fertility, and soil structure (Savci, 2012). The use of inorganic chemical fertilizers should be reduced and replaced bybiofertilizers as it enhances soil fertility and productivity, maintain agro-ecosystemandsustainable agriculture production and is also cost effective as compared to inorganic fertilizers (Raja, 2013).

Biofertilizers contain the living micro-organisms known to help for better root expansion, and seed germination (Chen, 2006). They consist of microbes capable of nitrogen fixation, phosphate mineralization, phytohormone production and bio-control which are essential for plant growth and enhance the yield of crops and soil fertility (Naveed, Mehboob, Shaker, Baqir Hussain, & Farooq, 2015).The production process of biofertilizer technologyis simple andrequires less energy, capital, technologyandhuman resourceswhereasinorganic fertilizer production requires huge energy, high capital and large number of human resources(Raimi, Adeleke, & Roopnarain, 2017).The research conducted in Sri-Lankaon factors constraining farmer's adoption of new agricultural technology present lack of resources, incompatibility and complexity of new technology, socio-economic and cultural constraints as the constraining factors for adoption of new technology in agriculture. The study also present extension intervention, technical training and information about technology as major constraint which compromised information and knowledge network(Silva & Broekel, 2016). In a study by Rowena Baconguis and his friends (Baconguis, Peñalba, & Paunlagui, 2012) on mapping the

innovation system of biofertilizers: constraints and prospects to enhance diffusion presents lack of awareness on the efficacy of biofertilizers compared to their familiarity with tried and tested use of inorganic fertilizers is major reason hindering adoption of biofertilizer. The study also points out inability of biofertilizer entrepreneurs to compete with inorganic fertilizer industry one of reason lacking adoption of biofertilizer

The socio-economic factors didn't influence access or adoption of technology but degree of use of the technology by a farmer was somehow related to socio-economic status (Rogers, 1995).In Nepal socio-economic factors which affect adoption of organic farming was studied by Mrinila Singh, Keshav lal Maharjan, Bijan Maskey (2015). This study shows that male headed and age of household leads to adoption of inorganic farming which is due to competitiveness to produce more and unable to hire labor. The study also shows farm size and farming experience has positive chance of adopting inorganic farming. It indicates the more education of household; more is adoption of inorganic farming whereas, if agriculture is primary occupation of household, it leads to adoption of organic practices. Also, the study indicates that, formation of group for organic farming doesn't ensure that all of its member will adopt organic farming(Singh, 2014).

The use of biofertilizerssubstituting chemical fertilizer technology will not only increase productivity and profitability of small holder farmers, it will build a robust agricultural economy in Nepal. Despite of these facts, the adoption of biofertilizers in agriculture is not satisfactory.Thus, this research aims to presentfactors affecting the adoption of biofertilizers.

2. Objectives

The general objective of this research is to study the factors affecting adoption of biofertilizers in Chitwan districtof Nepal whereas the specific objectives are:

- To study the socio-economic characteristics of farmers affecting the adoption of biofertilizers in Chitwan
- To know the level of knowledge of biofertilizers in farmers
- To find out the problems affecting the adoption of biofertilizers in Chitwan

2. Methodology and Materials

2.1 Study area and Sample Selection

Geographically, Nepal is divided into Himalayan Region, Hilly Region and Terai Region. Since Chitwan district is one of the major commercial farming region of Nepal, this research was conducted in Chitwan district which is located in Terai and towards the Southern part of Nepal. The study area was divided into six clusters (Rapti, Kalika, Khairehani, Ratnanagar, Bharatpur and Madi) considering each municipality as a cluster. Two hundred samples were selected by simple random sampling technique within the clusters, without replacing it and at least 30 samples were selected from each cluster. The survey was conducted for a month of January in 2018 and sample was collected through semi structured interview among the farmers.

Formation of clusters help to include total population of the district, where as simple random sampling was done to select a farmer with higher experience and agriculture as their main source of income. This helps to determine real problem of the farmers affecting the adoption of biofertilizers.

2.2 Empirical model

The collected data was analyzed using binary logistic regression model using SPSS 24. Binary logistic Regression model is considered to be an appropriate tool when there are two categorical dependent variables with no such ranking or ordering with independent variables that can be continuous, categorical or a mix of continuous and categorical(Hosmer & Lemeshow, 2000).

The dependent variable is dichotomous, the dependent variable can take the value 1 with probability of success (π) or the value 0 with probability of failure (1-π). Logistic regression makes no assumption about the distribution of the independent variables. They do not have to be normally distributed, linearly related or of equal variance within each group.

The probability of success (π) in logistic model,

$$P(\pi) = \frac{e^{\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_n x_n}}{1+e^{\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_n x_n}} \quad \ldots\ldots\ldots\ldots (1)$$

P: probability of success

e: natural logarithm base

β_0: interception at y-axis

$\beta_1\beta_2,\ldots\beta_n$: regression coefficient of x_1, x_2….x_3

x_1, x_2, …, x_n: predictor variable which predicts the probability of success (π)

Logit transformation of probability of success can be represented by following equation,

$$\ln(\pi) = \ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n \quad \ldots\ldots\ldots\ldots (2)$$

Here in this study the dependent variable is dichotomous, the adoption of biofertilizer take the value 1 with probability of success(π), whereas the non-adoption of biofertilizer take the value 0 with probability of failure (1-π).

The empirical specification for this study is as follows:

$$\ln(Adoption) = \beta_o + \beta_1 age + \beta_2 gender + \beta_3 education + \beta_4 primary\ occupation + \beta_5 farming\ experience + \beta_6 farm\ income + \beta_7 farm\ size + \beta_8 training + \beta_9 group\ membership + \beta_{10}\ municipality/metropolitan + \mu$$

Where, ln is natural log, μ is an error term and β_0 is intercept whereas $\beta_1, \beta_2 \ldots . \beta_{10}$ represents the coefficient of regression of each independent variable.

3. Results and Discussions

3.1 Descriptive analysis

Table 1 and 2 are the descriptive analysis of socio-economic characteristics of the respondents.

Table 1: Explanatory socio-economic variables affecting the adoption of biofertilizer

Variables	Adoption of biofertilizer		Total	P – value
	Apply	Don't apply		
Age of the respondents				
<40 years	14 (7)	19 (9.5)	33 (16.5)	0.686
40 to 68 years	49 (24.5)	84 (42)	133 (66.5)	
>68 years	17 (8.5)	17 (8.5)	34 (17)	
Total	80 (40)	120 (60)	200 (100)	
Gender				
Male	71 (35.5)	95 (47.5)	166 (83)	0.127
Female	9 (4.5)	25 (12.5)	34 (17)	
Total	80 (40)	120 (60)	200 (100)	
Education level of respondents				
Illiterate	11 (5.5)	16 (8)	27 (13.5)	0.982
Basics (up to 5 years of schooling)	25 (12.5)	46 (23)	71 (35.5)	
Secondary (6 to 10 years of schooling)	30 (15)	46 (23)	76 (38)	
Higher Secondary (11 to 12 years of schooling)	13 (6.5)	10 (5)	23 (11.5)	
Bachelors and above (> 12 years of schooling)	1 (0.5)	2 (1)	3 (1.5)	
Total	80 (40)	120 (60)	200 (100)	
Primary occupation				
Agriculture	43 (21.5)	92 (46)	135 (67.5)	0.003***
Non-Agriculture	6 (3)	12 (6)	18 (9)	
Agriculture and Business	17 (8.5)	7 (3.5)	24 (12)	
Agriculture and Employment	14 (7)	9 (4.5)	23 (11.5)	
Total	80 (40)	120 (60)	200 (100)	
Farming Experience				
Short duration (<15 years)	9 (4.5)	22 (11)	31 (15.5)	0.235
Medium duration (15-45 years)	55 (27.5)	84 (42)	139 (69.5)	
Long duration (>45 years)	16 (8)	14 (7)	30 (15)	
Total	80 (40)	120 (60)	200 (100)	
Farm Income				
<NRs. 12000	2 (1)	7 (3.5)	9 (4.5)	0.097*
NRs.12000 to NRs. 353000	58 (29)	103 (51.5)	161 (80.5)	
>NRs. 353000	20 (10)	10 (5)	30 (15)	
Total	80 (40)	120 (60)	200 (100)	
Farm size				
Small size (<0.5 ha)	25 (12.5)	70 (35)	95 (47.5)	0.006***
Medium size (0.5 to 2.06 ha)	46 (23)	48 (24)	94 (47)	
Large size (>2.06 ha)	9 (4.5)	2 (1)	11 (5.5)	
Total	80 (40)	120 (60)	200 (100)	
Group Membership				
Yes	49 (24.5)	69 (34.5)	118 (59)	0.574
No	31 (15.5)	51 (25.5)	82 (41)	
Total	80 (40)	120 (60)	200 (100)	
Training				
Yes	13 (6.5)	3 (1.5)	16 (8)	0.028**
No	67 (33.5)	117 (58.5)	184 (92)	
Total	80 (40)	120 (60)	200 (100)	
Municipality/Metropolitan				
Rapti Municipality	14 (7)	20(10)	34(17)	0.770
Khairehani Municipality	8 (4)	23 (11.5)	31 (15.5)	
Kalika Municipality	9 (4.5)	21 (10.5)	30 (15)	
Ratnanagar Municipality	13 (6.5)	17 (8.5)	30 (15)	
Bharatpur Metropolitan	19 (9.5)	26 (13)	45 (22.5)	
Madi Municipality	14 (7)	16 (8)	30 (15)	
Total	80 (40)	120 (60)	200 (100)	

Source: (Field Survey, 2018)

Note**:** Figure in parenthesis indicate percentage, ***at 1%, **at 5% and * at 10% level of significance

It is found that about 67% of respondents were of age group from 40 years to 68 years. Only 17% of the households are female-headed which is coherent as Nepalese society is mainly patriarchal-based. About 14% of respondents are illiterate whereas 36% of them are having only basic level of education. About 68% of respondents are following up the agriculture as their primary occupation. While asking the respondents how long they have been following the farming system, it is identified that with the minimum of 2 years to maximum of 75 years, the average farming experience is of about 30 years and about 70% of them are from 15 years to 45 years of farming experience. The size of farm ranges from 0.06 ha to 10.67 ha with the average being about 0.8 ha. The annual farm income ranges from NRs. 2000 to NRs. 800000 with the average being about NRs.183000. About 60% of respondentsare engaged in farmers groups or co-operatives. Only 8% of them have received training on the use of biofertilizers.

Table 2: Measurement and summary of explanatory variables and their hypothesized relation to adoption of biofertilizer

Explanatory Variables	Definition and Measurement	Mean ± Standard Deviation	Expected Sign
Age	Age of Respondent; years (discrete)	54.17 ± 13.863	+/-
Gender	Gender of Respondent; 1= Male, 2= Female (dummy)	1.17 ± 0.377	+/-
Education	Education of respondent; years (discrete)	1.52 ± 0.9186	+
Primary_occupation	Primary occupation of Respondent; 1= Agriculture, 2= Non-agriculture, 3= Agriculture and Business, 4= Agriculture and Employment (nominal)	1.675 ± 1.075	+
Farming_experience	Farming Experience of Respondent; Years (discrete)	29.745 ± 15.276	-
Farm_income	Farm income of Respondent; Nepalese Rupees (NRs) (continuous)	182760.00 ± 170492.613	+/-
Farm_size	Operational farm size; Hectare(ha)(continuous)	0.793 ± 1.284	-
Group_membership	Membership in Organization; 1= Yes, 2= No (dummy)	1.41 ± 0.493	+
Training	Biofertilizer related training received; 1= Yes, 2= No(dummy)	1.92 ± 0.272	+
Municipality_Metropolitan	Address of Respondent; 1= Rapti, 2= Khairehani, 3= Kalika, 4= Ratnanagar, 5= Bharatpur, 6= Madi(nominal)	3.745 ± 1.725	+/-

Source: (Field Survey, 2018)

It is found that only 40% of respondents use biofertilizers. The problems, due to which remaining 60% of them are not using biofertilizers, were identified and ranked as shown in Table 3.

Table 3: Problems of biofertilizer adoption in Chitwan district

Problems of biofertilizer adoption	Frequency (N = 120)	Percentage	Ranking
Availability of biofertilizer	3	2.5	5
Knowledge gap on use of biofertilizer	64	53.53	1
Not beneficial	5	4.17	4
Tradition of using chemical fertilizer	32	26.67	2
Not effective	1	0.83	6
Availability of sufficient FYM	15	12.5	3
Total	120	100.0	

Source: (Field Survey, 2018)

Knowledge gap on use of biofertilizer and tradition of using chemical fertilizer are found to be the two major factors affecting adoption of biofertilizer in Chitwan district.

3.2 Result fromBinary Logistic Regression Model

The probability of the model chi-square (33.212) is highly significant at 1% which supports the existence of relationship between the dependent and explanatory variables. The Pseudo R^2 suggests that about 21% of the total variation in the values of dependent variables is expressed by the independent variables in this regression equation (Table 4).

Table 4: Result from Forward LR method of binary logistic regression model

Variables	Adoption of biofertilizers	
	Coefficient	P-value
Gender	2.335	0.127
Age	0.163	0.686
Education	0.000	0.982
Primary Occupation	-0.248	0.003***
Farming Experience	1.408	0.235
Farm size	-0.798	0.006***
Farm Income	2.757	0.097*
Group Membership	0.316	0.574
Training	1.546	0.028**
Municipality/Metropolitan	0.086	0.770
Constant	-0.763	0.612

Source: (Field Survey, 2018)
***at 1%, **at 5% and * at 10% level of significance
Number of observations = 200

LR chi square = 33.212 Prob.> chi2 = 0.000
-2 Log likelihood = 325.992 Pseudo R2 = 0.207

The result from binary logistic model showed the expected result for farm size and training. Three predictor variables i.e. primary occupation, farm size, and training showed significant relation on adoption of biofertilizer among which training has positive relation with the adoption of biofertilizer. Primary occupation showed a negative relation with adoption to biofertilizer with significant value at 1 % level of significance i.e. farmers are more likely to adopt chemical fertilizers as compared to biofertilizers. Lack of awareness and extension education about use of biofertilizer is a reason for less adoption of biofertilizers. Similarly, farm size showed negative but significant relation with adoption process of biofertilizer with 1 % level of significance. Larger the farm size for production competitiveness, less chance of adoption of biofertilizer. Farming experience has positive relation with adoption of biofertilizer but the relation is insignificant. This shows higher the farming experience; more likely a farmer has chance of adopting biofertilizer. Farmer with lower age and farming experience tends to tilt more over towards adopting chemical fertilizers, which is due to their willingness to increase production more competitively for higher profit.
The farm income from relation shows that higher the farm income, higher the chance of adopting biofertilizer but the relation is insignificant. But with 10 % level of significance, farm income shows significant result. Training on biofertilizer about its use and efficiency shows the positive and significant

relation with adoption of biofertilizers with 5 % level of significance. This result shows more the training and extension education on biofertilizer, it leads to higher level of adoption for biofertilizers. Similarly, membership of farmers ingroups or co-operatives have better chance of adopting biofertilizer as group membership shows positive but insignificant relation with adoption of biofertilizer. The result deviate from study of Mrinila Maskey and friends (2015), for age and gender which shows positive but insignificant result with adoption process.

4. Conclusion and recommendations

The propose of this research is to analyze the factors affecting the adoption of biofertilizers in Chitwan district of Nepal. Cluster sampling is used to collect the 200 samples, at least 30 samples from each cluster. binary logistic regression model used for data analysis. Study showed that primary occupation and farm size were negatively significant with adoption of biofertilizers. It may be due to lack of knowledge about the use of biofertilizers and competitiveness for producing more from less farm unit. The traditional way of farming may be the reason for farmers lagging behind the use of biofertilizers. The commercial farmers with large farm size don't use the biofertilizers as because they are more profit-oriented and also may be due to lack of sufficient amount of biofertilizers for large farm size. The study also showed that training is positively significant with adoption of biofertilizers. Training on use of biofertilizers for farmers will help to adopt the biofertilizers in their field.

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