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Utilizing Biofertilizer for Achieving Sustainable Agriculture and Rural Development Strategy towards Vision 2040, Oman

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Abstract: The agriculture industry in the Western world is increasingly using biofertilizers, considering the environmental aspects and organic food. Sustainability in agriculture is the primary priority of the government of the Sultanate of Oman. In order to improve and develop the agricultural sector for community development, the government of Oman is paying special attention to its Vision 2040 in line with sustainable development goals. Hence, the aim of the research is to analyze the behavioral aspects of farmers and farmholders towards utilizing biofertilizers for saving the environment as well as providing organic food and bringing sustainability to the agriculture sector of the country. In order to meet the objectives of the study mixed method research has been used. An interview guide has been developed, a questionnaire has also been developed, and the instruments have been approved by the experts. The interview data were analyzed, and afterward, primary data were collected. To test the hypothesis and the framework, Smart PLS 3 has been used. The findings identified that farmers in Oman are reluctant to use biofertilizers because of a lack of awareness, but yet they are using it up to some extent and the proposed model has proven to be significant. The findings are useful not only for the policymakers but also for the practitioners who can obtain guidance about the benefits they can gain from the use of biofertilizers.

Keywords: biofertilizer; sustainable agriculture; community development; productivity

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1. Introduction

Throughout the world, especially in developed countries, the use of biofertilizers is increasing because of the universal problem of environmental degradation from the overuse of chemical-based fertilizers. In the current era, sustainability and sustainable practices are gaining significant importance around the globe [1,2], and the agriculture sector of Oman is no exception. Now, the world is considering sustainability and innovation in almost all fields, including the agriculture sector [3,4]. Thus, the social burden is placed on farmholders of developing countries to utilize sustainable practices, which have a significant impact [5] on the environment and community development [6].

Biofertilizer proves to be as effective as mineral sources and provide ammonia in an environmentally friendly way [7]. Biofertilizers in developing and underdeveloped countries are slug and cow dung, containing beneficial microorganisms that improve soil quality and fertility [8]. The use of biofertilizers enhances crop productivity, which is crucial for the environment because of reduced dependency on chemical-based fertilizers [9]. Developed countries are conducting significant research on formulating mechanisms for the use of biofertilizers for obtaining a high level of nutrition, enhanced soil fertility, and sustainable agriculture, and Oman is no exception because of its Vision 2040 for sustainable agriculture and rural development strategy. According to the World Bank, only 4.7374% of the total land of Oman is agricultural land, which is almost 1.4 million hectares [10]. The

contribution of the agriculture sector to the Gross Domestic Product is only 1.84%, which is very low, and provides employment to only 6.0652% of the population. At the same time, the government of Oman is highly interested in achieving sustainability in agriculture to become self-sufficient in food, and the government aims to achieve sustainability in agriculture through renewable sources [11]. Biofertilizer is considered the leading option for gaining sustainable agriculture without compromising on the environment [12]. The agricultural sector in Oman produces only dates, coconut, banana, and watermelon, along with a few vegetables. Considering the Vision 2040 of Oman, where one of the goals is to achieve sustainable agriculture and community development, this study is proposed in the setting of the Sultanate of Oman to aid Vision 2040.

However, the lack of research resulted in a fall in the confidence of farmers in using biofertilizers, which convinced them to use traditional chemical-based fertilizers [13]. Meanwhile, Oman is experiencing low productivity in the agriculture sector, due to which the country has to rely more on the import of agricultural products [14]. Hence, there is a dire need for empirical research in the Sultanate of Oman to highlight the concept of biofertilizers, as the concept is quite new in the Sultanate of Oman. Instructions and strategies can generate explicit intellectual and emotive impact on farmholders and may affect their choices and behaviors towards the adoption of biofertilizers for sustainable agriculture.

The development and market inclusion of new forms of fertilizers, i.e., biofertilizers, will potentially reduce the dependence on mineral sources and will promote a circular economy and sustainability [15]. Hence, the utilization of biofertilizers is not only beneficial from an environmental perspective but also from an economic perspective. Furthermore, Ataei et al. [13] focused on the theory of planned behavior and linked it with sustainable agriculture but failed to focus on the outcome variable, which is community development. Organic forms of waste (e.g., manure, sludge) are commonly used in agriculture in developed countries; however, wastage of the same in developing countries causes environmental hazards [12]. The lack of use of biofertilizers in developing countries is mainly due to a lack of awareness, high logistic costs, seasonal restrictions, or lack of legislation [16].

Furthermore, recent studies have tested agricultural effects on greenhouse emissions (GHG) for the addition of biofertilizers (e.g., biochar) in different soils [17], yet hardly any research has been conducted in the Sultanate of Oman. Thus, the importance of utilizing biofertilizers cannot be ignored. In the Sultanate of Oman, the Dhofar region, especially Salalah, is renowned for agriculture and cattle farming; however, hardly any research has been conducted on the effective utilization of cow dung or slug. Lack of research results in excessive utilization of chemical-based fertilizers, production of non-organic food, and excessive waste produced in the environment due to lack of utilization of cow dung.

Hence, considering the advantages of utilizing biofertilizers and the lack of adoption of the same in the Sultanate of Oman, this study is being proposed to understand the underlying reasons from the perspectives of farmers and farm holders. The research will utilize the underpinning support of the Theory of Planned Behaviour (TPB) and Expected Utility Theory (EUT) to measure intentions to adopt biofertilizers for sustainable agriculture and community development. The main contribution of the study is utilizing these two theories together to bring sustainability in agriculture and linking the theories with community development. TPB mainly talks about behavioral intentions, whereas this study focused on implementation as well as the outcomes in the form of community development.

Likewise, EUT also talks about the utility of the implementation, whereas this study focused on the use of biofertilizer for achieving more than the utility in terms of productivity, but also in terms of sustainability in agriculture. Furthermore, the study extends the models to community development because by achieving sustainability in agriculture, more land can be brought to cultivation, which will certainly improve production, employment, and

self-reliance on food. Considering the above discussion, the study focused on achieving the following objectives:

1. To explore the behavioral intentions of farmers and farmholders towards the use of biofertilizers;
2. To find the impact of the attitude of farmers towards using biofertilizers for sustainable agriculture;
3. To find out the impact of subjective norms of farmers towards using biofertilizers for sustainable agriculture;
4. To find out the impact of perceived behavioral control of farmers towards using biofertilizers for sustainable agriculture;
5. To find out the impact of cost-benefit analysis made by farmers towards using biofertilizers for sustainable agriculture;
6. To find out the impact of risk perception of farmers towards using biofertilizers for sustainable agriculture;
7. To find out the impact of using biofertilizers for sustainable agriculture over community development.

2. Literature Review and Related Work

The basic underpinning support in this study is taken from the Theory of Planned Behaviour (TPB) [18] and Expected Utility Theory (EUT) [19]. TPB considers that human beings perform their behaviors based on attitudes, subjective norms, perceived behavioral control, cost and benefit analysis, and risk perception. In this study, the variables identified by the theory are taken as a basis behind the behaviors of farmers in utilizing biofertilizers in their agricultural activities. In addition to that, EUT talks about the mathematical models for decision-making making are taken to strengthen the propositions made. The two theories form the theoretical basis for developing the model and extending it to community development. Community development in this study is measured considering the increased productivity, increased economic activity, increased utilization of land, and increase in employment.

It is well known that TPB mostly supports the arguments related to social psychology literature, whereas expected utility is primarily used in economic literature. It is important to note that neither theory has been able to identify the root reasons for the adoption of a particular behavior or product. Utilizing TPB and EUT collectively will explain the phenomenon in detail by understanding the cost and benefit analysis as well as behavioral aspects of farmers and farmholders for utilizing biofertilizers. Therefore, to further strengthen the concept of advantages that can be gained from the utilization of biofertilizers, the researchers proposed to add EUT with the core constructs of TPB; it may theoretically explain behavioral intents along with linking the same with cost and benefit analysis.

The majority of the studies that have been conducted on the agriculture sector identified the socio-economic impact and consider the same to be an effective force behind the adoption of modern farming [18,19]. Socio-economic factors hardly influence the use of biofertilizers; however, the socio-economic status of the farmer or farm owner influences the degree of utilizing biofertilizers, and socio-economic factors lead to community development. The knowledgeable farmers use biofertilizers because they contain microorganisms, which expedite the process of seed germination and help in better expansion of the roots [20].

On the other hand, excessive usage of chemical fertilizers has significant negative effects on the productivity of the crops, fertility of the soil, and structure of the soil [21]. Moreover, the production process of biofertilizers is simple. The production requires minimal energy, capital, technology, and human resources. However, biofertilizer production requires huge energy, high capital, and a large number of human resources. The majority of researchers have identified these aspects but have mainly ignored the behavioral aspects of the farmers. Moreover, the added advantages from the use of biofertilizers have not been

identified especially the community development, which the current research is taking as an outcome variable.

Lack of resources, incompatibility, complexity of new technology, and socio-economic and cultural constraints are the retarding factors behind the adoption of biofertilizers in agriculture in the majority of countries [22]. Researchers have identified that farm size and farming experience have a positive influence on adopting inorganic farming [23]. Some researchers claimed that group formation and providing training could have a significant impact on the utilization of biofertilizers [24]. However, some researchers refuted the claim and identified that group formation for utilizing biofertilizers does not guarantee that all the group members will follow organic farming [20]. Hence, considering the above discussion, it seems to be obvious that perceptual and behavioral aspects significantly influence the adoption of biofertilizer technology by farmers and farmholders.

Upon adoption of biofertilizers, it can be seen that more area can be cultivated, and more employment can be generated for the handling of slug; hence, an increase in income, as well as an increase in employment, will certainly lead to community development.

The Theory of Planned Behavior is helpful in supporting external social influences in utilizing biofertilizers along with the perceptual as well as ability of the farmers and farm holders to use biofertilizers. Moreover, the Expected Utility Theory will provide support for understanding the perceived associated risks and rewards of utilizing biofertilizers. Therefore, based on the above discussion, the following framework has been developed, which will be tested through empirical research.

The framework in Figure 1 represents the behavior of farmers in using biofertilizers for sustainable agriculture, which will ultimately lead to community development as an outcome variable. Based on the above framework the data has been collected through a developed questionnaire. The next Sections describe the methodology which has been applied in this study.

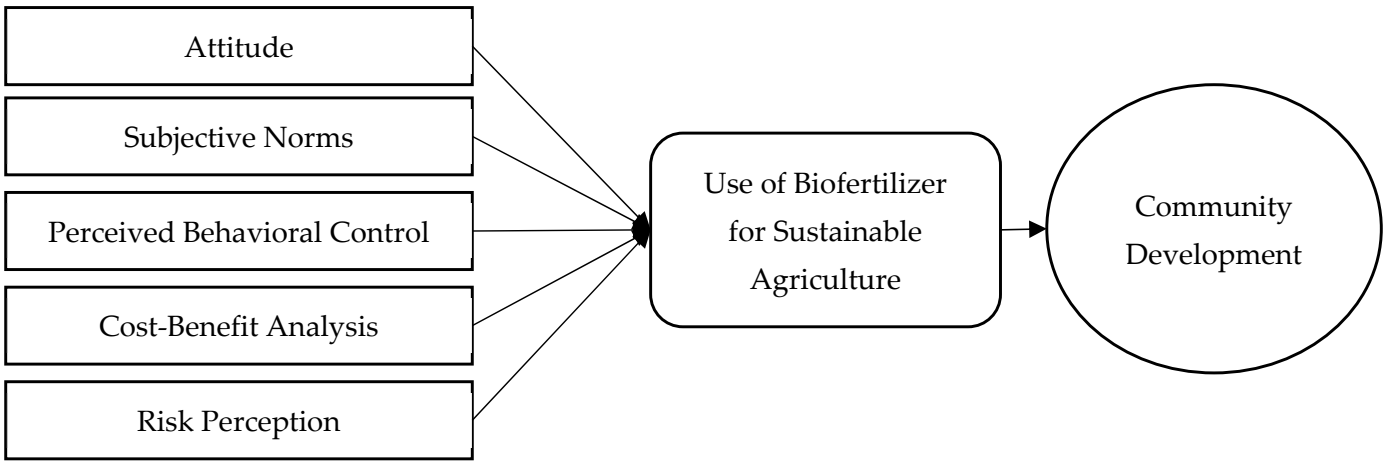

Figure 1. Research Framework.

3. Research Methods

In order to satisfy the objectives of the study, a survey was carried out among the farmers and farmholders living in the rural areas of the Sultanate of Oman. Most of the farm owners have animals on their farms, particularly those farmholders who were chosen for the interviews who had animals in their farms. In order to meet the objectives of the research mixed methodology research has been used. Initially, the behavioral aspects of the farmers towards the use of biofertilizer were explored through open-ended interviews to dig out the issue of why biofertilizer is hardly used by the farmers in Oman. The interview questions (Appendix B) were made based on the literature reviewed and the behavioral aspects identified in the literature, for using or not using biofertilizer. Later

on, the questionnaire (Appendix A) was developed based on the responses of the farmers considering the five dimensions of TPB and EUT.

Initially, the interviews were conducted with farmers residing in different rural areas of the Sultanate of Oman. For a qualitative study, the ideal sample size is 10 to 15 [25]; some claim that 12 to 13 interviews are enough [26]. Following the rule of thumb, the interviews were discontinued when the data saturation started [27]. Hence, based on this, in total, nine interviews were conducted, as the data saturation point started at the eighth interview. The data collected from the interviews were transcribed and content analysis was performed to identify the key aspects that were explored about the use of biofertilizers.

Afterward, quantitative analysis was conducted with the help of a developed questionnaire containing closed-ended questions. The list of farmholders was obtained from the Agriculture and Farming—ABC Oman Business Directory. The questionnaire was applied to a randomly selected sample through the software out of the population drawn from the list. A total of 384 respondents were involved to finalize the findings of the study, as this size is considered as most appropriate for social sciences [28,29]. The questionnaire was developed based on the prior studies, a literature review [12,13,20,30], and interview results. Furthermore, the questionnaire was sent to the expert for the content and face validity and the questionnaire was modified as per the instructions given by the expert. Furthermore, the questionnaire has been attached at the end for the reference of future studies. The instrument provided information to test the acceptance of biofertilizers for sustainable agriculture, and the outcome variable community development has also been measured through the questionnaires covering the aspects of employment generation, income generation, and increased economic activity for the betterment of the socio-economic standard of the people. The survey contained three segments: the first covered the demographic factors of farmers and farm holders, the second set contained the questions that covered the five factors that were developed based on the Theory of Planned Behavior and Expected Utility Theory, and the final portion covered the behavior of formers towards adoption of biofertilizers for sustainable agriculture as well as community development. The responses were measured using a 7-point Likert Scale as it increases the sensitivity but gives more precise answers. The data has been collected from 384 farmers and farmholders. Initially, SPSS 25 was used to test the descriptive analysis; afterward, SMART PLS was used for testing the hypothesis, as it is considered good for theory building.

4. Results

The analysis has been divided into two portions. The first part contains the qualitative analysis where the data from the interviews were analyzed. The second part contains quantitative analysis where initially the reliability and validity of the instrument were checked, followed by the Partial Least Square Structural Equation Modelling (PLS-SEM).

4.1. Qualitative Analysis

The data collected from the interviews were analyzed in the following steps. Initially, the entire data were transcribed, and afterward, the annotations were added. The entire dataset was conceptualized based on the perceptions of the farmers for the use of biofertilizers. Then, the data were segmented, and main themes were developed, and finally, the writeup was made over the results that were drawn from the data collected through interviews. The interview responses were divided into the following themes, and the analysis is mentioned below.

4.1.1. Preference for Using Cow Dung or Camel Dung

Respondent's answers were different from each other, Some of the respondents were in favor of camel dung or cow dung because it is good for production, and other respondents preferred fertilizer Kamil and Yuriria. As one of the respondents said, "It is good to fertilize the soil from time to time".

4.1.2. Current Usage of Cow Dung or Camel Slug

Respondents said that cow dung or camel slug is economical and very easy to use, and some suggested finishing cow dung or using only natural fertilizers. As one of the respondents claimed, "We believe that they are natural, but not beneficial, like urea".

4.1.3. Cost-Effectiveness of Cow Dung or Camel Slug

Respondents said that if we compare fertilizers like urea with biofertilizers like cow dung or camel slug, then cow dung is inexpensive and very beneficial for maintaining the fertility of the soil, which is necessary for the sustainability of agriculture. As one of the respondents said, "They are healthy and free".

4.1.4. Comparison with Chemical-Based Fertilizers

Organic fertilizers, cow dung and camel dung, will not harm the environment as compared to chemical-based fertilizers; the growth of organic fertilizers is very slow, but respondents prefer them. As one of the respondents identified, "It is better and has more benefits".

4.1.5. Benefit for Soil Fertility

Many respondents believe that camel dung and cow dung have a good impact on soil fertility and enrich the soil with nutrients because it is all-natural, while urea is chemical and is not considered beneficial in the long run. As one of the respondents pointed out, "I never use urea because I do not trust".

4.1.6. Risks Involved in Using Cow Dung or Camel Dung as Fertilizer

The risk of using camel slug and cow dung as fertilizer was acknowledged by respondents. It includes the existence of weeds and seeds to prevent unfavorable effects on plant growth; however, yield is compromised because natural fertilizers hardly give the same yield. Moreover, it increases the time for the maturity of the crop. In this regard, a respondent claimed, "I saw the difference and the original fertilizer is taking too much time".

4.1.7. Farmers Perceptual Beliefs

Farmers believe that camel dung and cow dung are natural and healthy, which is why it is good for enhancing soil fertility. For that reason, they use them as fertilizers because chemical fertilizers are expensive and not good for the soil. As one of the respondents said, "However, chemical base fertilizers harm the trees".

4.1.8. Farmers Acceptance

The use of camel dung and cow dung as fertilizers was accepted by some farmers because it has more advantages and is all-natural whereas some prefer chemicals as fertilizer. As one of the respondents said, "Natural fertilizers have no side effects".

4.1.9. High Yield Benefits

Soil fertility will increase if natural fertilizers such as camel and cow dung are used; it will increase the growth of healthy plants, and it will decrease the usage of chemical fertilizers which lead to achieving high yields.

In our opinion, based on the responses of the farmers, natural fertilizers are very useful because they are good for soil and plant growth, and we cannot ignore soil health and its fertility just to obtain high yield through chemical-based fertilizers. At the same time, it has been observed after overall qualitative analysis that farmers are not very informed about the advantages of biofertilizers, and they consider it only a cheap substitute for chemical-based fertilizers with minimum output. Their lack of knowledge is a major hindrance in the use of biofertilizers.

4.2. Quantitative Analysis

Based on the answers of farmers and farm owners the questionnaire was made to collect the quantitative data. The data has been collected with the help of a developed questionnaire. The data has been initially analyzed to check the descriptive analysis of the variables using SPSS 25. After ensuring that the data is normally distributed and the findings can be generalized, then the structural equation modeling was conducted using Smart PLS-3.

In structural equation modeling, the outer model has been initially analyzed to confirm the reliability and validity of the instrument. Analysis of the outer model started with identifying the item loadings, and once it was confirmed that all the items held sufficient item loadings, Cronbach's alpha, composite reliability, and average variance extracted were analyzed. In order to be sure that items used for measuring one variable are different from the other, discriminant validity is ensured using the Fornell–Larcker Criterion as well as HTMT methodology. Once it is ensured that the outer model is reliable, the inner model is assessed to check the relationships. The measurement is shown in Figure 2 which shows the outer model.

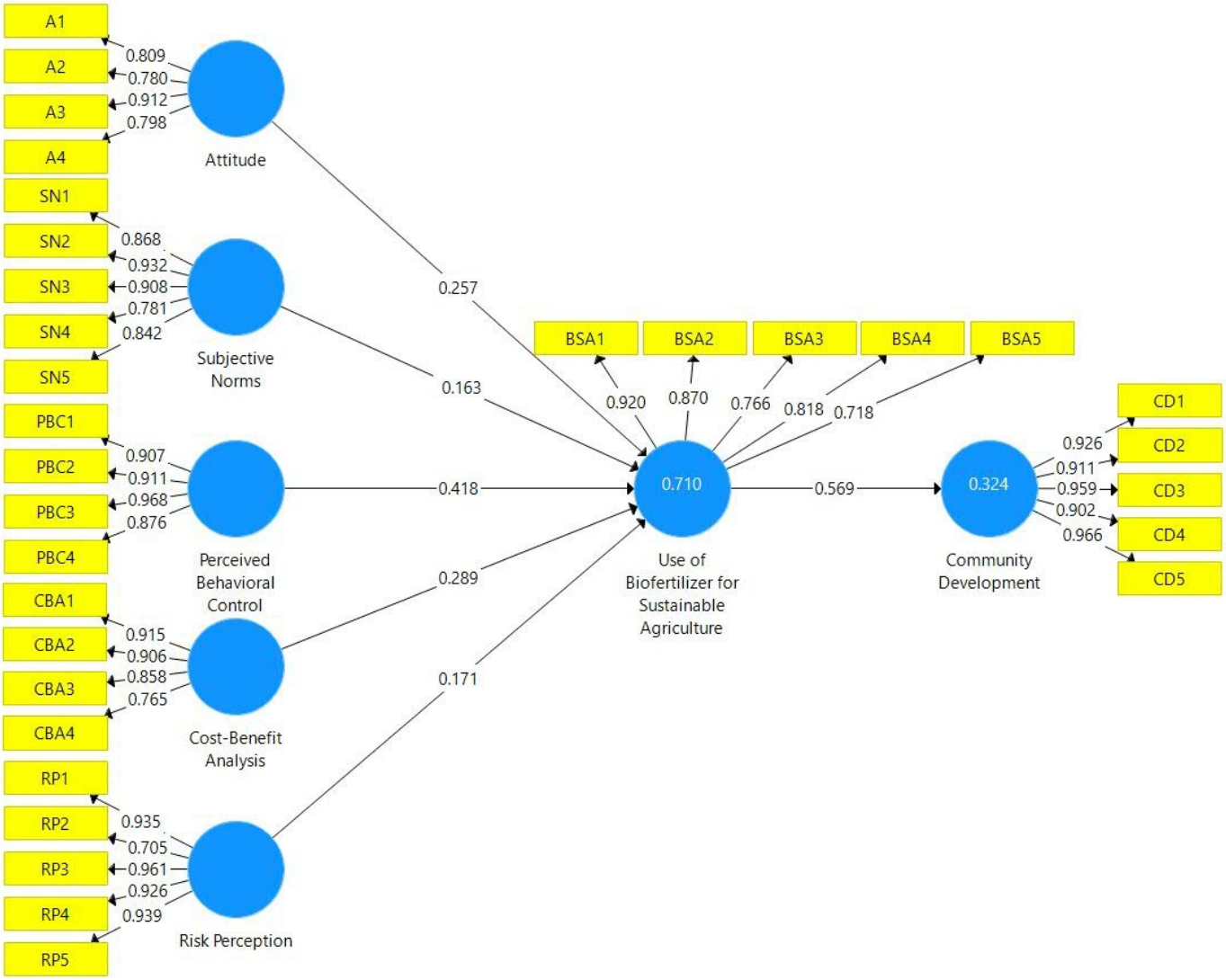

Figure 2. Measurement Model.

The study investigated the item loadings initially in order to determine the outer loading issues if associated with any variable. Quinlan, Zikmund, Babin, Carr, and Griffin,

2018 indicated that all the values in item loadings must be greater than 0.7. The findings of item loading for attitude, community development, cost-benefit analysis, perceived behavioral control, risk perception, subjective norms, and use of biofertilizer for sustainable agriculture have specific values ranging between 0.705 and 0.968, as shown in Table 1.

Table 1. Outer Loadings.

	Attitude	Community Development	Cost–Benefit Analysis	Perceived Behavioral Control	Risk Perception	Subjective Norms	Use of Biofertilizer for Sustainable Agriculture
A1	0.809						
A2	0.780						
A3	0.912						
A4	0.798						
BSA1							0.920
BSA2							0.870
BSA3							0.766
BSA4							0.818
BSA5							0.718
CBA1			0.915				
CBA2			0.906				
CBA3			0.858				
CBA4			0.765				
CD1		0.926					
CD2		0.911					
CD3		0.959					
CD4		0.902					
CD5		0.966					
PBC1				0.907			
PBC2				0.911			
PBC3				0.968			
PBC4				0.876			
RP1					0.935		
RP2					0.705		
RP3					0.961		
RP4					0.926		
RP5					0.939		
SN1						0.868	
SN2						0.932	
SN3						0.908	
SN4						0.781	
SN5						0.842	

Source: Own Analysis.

The results of outer loadings in Table 1 ensure that all items should be kept in the model as all item values are greater than the threshold level of 0.70.

4.2.1. Construct Reliability and Validity

The examination of construct reliability and validity in which the Cronbach's Alpha, Composite Reliability, and Average Variance Extracted (AVE) have been analyzed for attitude, community development, cost–benefit analysis, perceived behavioral control, risk perception, subjective norms, and use of biofertilizer for sustainable agriculture. Henseler, Ringle, and Sarstedt (2015) demonstrated that all variable values in Cronbach's Alpha should be greater than the threshold level of 0.7; meanwhile, other previous researchers argued that all variable values in composite reliability should be below 0.60 [28,29].

However, if the variable values are 0.7 or higher, they are considered highly significant. In addition, AVE reveals that the values of AVE measured are above the threshold level of 0.50 [30]. Hence, the analysis of construct reliability and validity for attitude, cost–benefit analysis, perceived behavioral control, risk perception, subjective norms, use of biofertilizer for sustainable agriculture, and community development are shown in Table 2.

Table 2. Reliability and Validity.

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Attitude	0.852	0.895	0.683
Cost–Benefit Analysis	0.884	0.921	0.745
Perceived Behavioral Control	0.936	0.954	0.839
Risk Perception	0.938	0.954	0.807
Subjective Norms	0.917	0.938	0.754
Use of Biofertilizer for Sustainable Agriculture	0.878	0.911	0.675
Community Development	0.963	0.971	0.871

Source: Own Analysis.

The analysis of all variables in Cronbach's Alpha for attitude, community development, cost–benefit analysis, perceived behavioral control, risk perception, subjective norms, and use of biofertilizer for sustainable agriculture values were 0.852, 0.963, 0.884, 0.936, 0.938, 0.917, and 0.878, respectively, whereas, the composite reliability for attitude, community development, cost–benefit analysis, perceived behavioral control, risk perception, subjective norms, and use of biofertilizer for sustainable agriculture values were 0.895, 0.971, 0.921, 0.954, 0.954, 0.938, and 0.911, respectively. Furthermore, the average variance extracted (AVE) for attitude, community development, cost-benefit analysis, perceived behavioral control, risk perception, subjective norms, and use of biofertilizer for sustainable agriculture values were 0.683, 0.871, 0.745, 0.839, 0.807, 0.754, and 0.675, respectively.

4.2.2. Discriminant Validity

It is important to analyze the discriminant validity to ensure that items used to measure one construct are different from the items used to measure the other construct. The study has examined discriminant validity for all variables: attitude, community development, cost–benefit analysis, perceived behavioral control, risk perception, subjective norms, and use of biofertilizer for sustainable agriculture, in which one latent variable is varied from the other latent variable. Hair, Black, Babin, Anderson, and Tatham (2010) stated that the Fornell–Larcker Criterion is the most standard technique for analyzing the discriminant validity. The calculated values of discriminant validity using the Fornell–Larcker criterion are shown in Table 3.

Table 3. Discriminant Validity by Fornell Larcker Criterion.

	Attitude	Community Development	Cost–Benefit Analysis	Perceived Behavioral Control	Risk Perception	Subjective Norms	Use of Biofertilizer for Sustainable Agriculture
Attitude	0.826						
Community Development	0.532	0.933					
Cost–Benefit Analysis	0.594	0.469	0.863				
Perceived Behavioral Control	0.466	0.569	0.644	0.916			
Risk Perception	0.617	0.566	0.688	0.567	0.898		
Subjective Norms	0.520	0.582	0.653	0.532	0.712	0.868	
Use of Biofertilizer for Sustainable Agriculture	0.645	0.569	0.722	0.734	0.649	0.503	0.821

Source: Own Analysis.

The outcomes of discriminant validity by the Fornell–Larcker criterion in the structural model show sufficient discriminant validity. In order to avoid any ambiguity, another

criterion is used to check discriminant validity, which is HTMT criteria. Discriminant validity has also been measured using HTMT criteria, as shown in the next section.

4.2.3. Discriminant Validity Using HTMT Criteria

Discriminant validity by Heterotrait–Monotrait Ratio (HTMT) criterion can be applied to check the discriminant validity and determine the average correlation of the indicators by variables, whereas, if the variable value of HTMT is less than 0.90, thus discriminant validity is established among variables [31]. Table 4 indicates the findings of discriminant validity by HTMT criterion.

Table 4. Discriminant Validity by Heterotrait–Monotrait Ratio.

	Attitude	Community Development	Cost–Benefit Analysis	Perceived Behavioral Control	Risk Perception	Subjective Norms	Use of Biofertilizer for Sustainable Agriculture
Attitude							
Community Development	0.566						
Cost–Benefit Analysis	0.671	0.502					
Perceived Behavioral Control	0.521	0.598	0.704				
Risk Perception	0.678	0.589	0.745	0.598			
Subjective Norms	0.585	0.618	0.718	0.576	0.760		
Use of Biofertilizer for Sustainable Agriculture	0.698	0.597	0.803	0.798	0.684	0.540	

Source: Own Analysis.

The above findings of discriminant validity using heterotrait–monotrait ratio (HTMT) indicate that all variable values are discriminant.

4.2.4. Direct Effects

In order to present an apparent picture of the direct effect outcomes, the study evaluated the path coefficients using structural equation modeling. The impact of attitude, cost–benefit analysis, perceived behavioral control, risk perception, and subjective norms over the use of biofertilizer for sustainable agriculture is mentioned in Table 5, as well as the impact of the use of biofertilizer for sustainable agriculture over community development, which is an outcome variable in the study.

Table 5. Direct Effects.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	*p* Values
Attitude-> Use of Biofertilizer for Sustainable Agriculture	0.257	0.25	0.124	2.071	0.039
Cost–Benefit Analysis- > Use of Biofertilizer for Sustainable Agriculture	0.289	0.246	0.102	2.827	0.005
Perceived Behavioral Control- > Use of Biofertilizer for Sustainable Agriculture	0.418	0.442	0.118	3.540	0.000
Risk Perception- > Use of Biofertilizer for Sustainable Agriculture	0.271	0.285	0.095	2.837	0.005
Subjective Norms- > Use of Biofertilizer for Sustainable Agriculture	0.263	0.248	0.105	2.496	0.039
Use of Biofertilizer for Sustainable Agriculture- > Community Development	0.569	0.557	0.131	4.360	0.000

Source: Own Analysis.

After the investigation of direct effects, the next essential stage is to ensure the predictive relevance of the model.

4.2.5. Predictive Relevance

The predictive relevance of the model is measured using construct cross-validated redundancy. Subsequently, the endogenous latent variable's Q^2 was determined by applying the Stone–Geisser test in the study. The analysis of construct cross-validated redundancy is shown in Table 6.

Table 6. Construct Cross-validated Redundancy.

	SSO	SSE	Q^2 (=1-SSE/SSO)
Community Development	495.000	362.300	0.268
Use of Biofertilizer for Sustainable Agriculture	495.000	280.681	0.433

Source: Own Analysis.

The findings of construct cross-validated redundancy showed that measured values for Q^2 are greater than zero, which ensures that the predictive relevance of the model is significant [32]. Moreover, it can also be seen that predictive relevance for community development is lesser than the use of biofertilizers.

5. Discussions, Conclusions, Significance and Recommendations

Gulf countries are engaged in conventional agricultural ways except for the UAE, which is moving towards the latest agricultural methodologies to improve productivity. However, they do not deviate towards organic food or the use of biofertilizers. Chemical-based fertilizers give high yield and productivity but result in the degradation of land along with loss of biodiversity. The current research highlighted and identified the considerations farmers have while utilizing biofertilizers, which leads to the advantages of using biofertilizers as per the perceptions of farmers for achieving sustainability in agriculture through sustaining soil.

The study was conducted in the rural areas of the Sultanate of Oman. The study has explored the issue through qualitative analysis and has confirmed through quantitative analysis the mechanisms that have the potential to change the intentions of the farmers for using biofertilizers. The findings have identified that attitude, cost–benefit analysis, perceived behavioral control, risk perception, and subjective norms have a significant impact on the use of biofertilizers, and the use of biofertilizers has a significant impact on community development in terms of earning, employment creation, use of more land for agriculture, and increasing the agricultural activities. Most of all, obtaining organic food is the demand of the current era.

The findings of the study are consistent with the prior studies where the researchers analyzed the use of TPB and found similar results [13,33–38]. The significance of the current study is that it further estimated the outcome variable, which is community development. The interviews revealed that the farmers in the Sultanate of Oman do consider the importance of using biofertilizers, but they are involved in it up to a lesser extent due to a lack of understanding and its advantages of obtaining organic food and bringing sustainability in agriculture.

5.1. Practical Significance

The findings of the study are helpful in achieving sustainability and affordability in agriculture. In order to keep the environment of Oman healthy and to challenge the issue of environmental degradation, the findings may act as a foundation document. Accepting the reasoning and emotional reactions can assist agricultural development authorities and agencies in conniving the farmers to overcome the obstacles in the adoption of biofertilizers. The findings significantly help the Sultanate of Oman in achieving "Sustainable Agriculture and Rural Development Strategy towards 2040 SARDS 2040". At the same time the

findings are helpful in establishing environmental concerns for adopting green practices in agriculture and producing organic food.

The expanded TPB will adjudicate their impact on the environmental concerns of farmholders as well as the government on the decision to facilitate the use of biofertilizers in the Sultanate of Oman. The findings are also helpful in achieving the objective of eco-friendly practices and sustainable agriculture. In addition to that, through the use of biofertilizers, more land can be utilized, which can help produce more employment, which can have a significant impact on community development. Therefore, practically the study findings can have dual advantages, one in terms of bringing sustainability in agriculture because of improved fertility of the land and secondly by creating more employment opportunities in the agriculture sector. The findings of the study hold more innovative significance by identifying the behavior of farmholders toward utilizing biofertilizers. The study highlighted the importance of utilizing biofertilizers for environmental sustainability, improved organic products, and an increase in employment. All these stated benefits collectively will result in community development. Based on the results, biofertilizer can be seen and introduced by the fertilizer supplier with regard to the marketing perspective, by way of raising the appeal of the brand as well as the environmental interest of farm holders and stressing the perception of eco-friendly environmental benefits. Thus, another business opportunity can also be created by implementing the concept of biofertilizers, as in developed countries, animal farm owners, especially dairy farms, are selling animal waste, which opens the horizon for several businesses. Considering the importance of the concept, policymakers may devise incentives for dairy farmers to sell the biowaste of the animals to gain more profits and to save the environment.

5.2. Theoretical Significance

The findings of the study contribute significantly to developing the understanding of the aspects that may change the behavior of farmers toward using biofertilizers. Understanding those aspects may also help in guiding the farmers' intentions in decision-making for utilizing biofertilizers. Expanding the TPB and EUT to biofertilizers, which has already been used previously to analyze the behavior of farmers and farmholders for utilizing biofertilizers, this study extended the same model to community development, including employment generation and income growth through utilizing more land for agriculture. Furthermore, the findings suggested that attitude, perceived behavior control, subjective norms, cost and benefit analysis, and risk perception all belong to the individual behavior aspects of the farmers. Another feature that shapes their behavior is linked with the EUT, which helps them to understand and calculate risk. The combined implementation of the two theories over behavioral aspects of farmers for utilizing biofertilizers for achieving sustainability in agriculture and extending the same to community development is the main theoretical contribution of this study. The findings of the current research will not only be useful theoretically but will also be effective for policymakers and farmholders in the Sultanate of Oman. The policymakers can obtain an idea about the threats the farmers have and can provide remedial measures as well as proper training that will eliminate the concerns of the farmers. This study will highlight the need for legislation and policy-making toward the adoption of innovation in farming and adopting green practices for sustainable agriculture through limiting the need for chemical based fertilizers.

5.3. Limitations and Recommendations

Despite the fact that the study is unique in its kind in the contextual settings of the Sultanate of Oman, the developed instrument must be analyzed in other environmental settings as well as in those areas where cow dung is available, such as Australia, Pakistan, India, and other, similar countries where dairy farming is a huge business. Moreover, the personal bias of farmers for not using the biofertilizer as despite protecting the land, the production is relatively low. Therefore, their answers might not be completely free of bias; thus, observations and other qualitative methodologies are also recommended for

the researchers. In addition to that, a study needs to be conducted covering the cost and benefit analysis of using biofertilizer and urea, which can compare the productivity and future fertility of the soil.

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Appendix A Questionnaire

Appendix A.1

Demographic

Age:	20 to 30	30 to 40	40 to 50	50 and above
Gender	Male		Female	
Qualification	High School	Graduate		Masters

Appendix A.2

Attitudes

Choose the correct option based on your perception where 1 stands for strongly disagree and 7 stands for strongly agree.

No.	Items	1	2	3	4	5	6	7
1	Using biofertilizer is good for the land.							
2	Using biofertilizer is harmful for the land.							
3	Using biofertilizer is a pleasant experience.							
4	Using biofertilizer is worthless.							

Subjective norms

Choose the correct option based on your perception where 1 stands for strongly disagree and 7 stands for strongly agree.

No.	Items	1	2	3	4	5	6	7
1	Most farmers who are important to me use biofertilizer.							
2	Most people who are important to me think it is good to use biofertilizer.							
3	Most people who are important to me want to use biofertilizer.							
4	It is expected of me to use biofertilizer.							
5	I feel under social pressure to use biofertilizer.							

Perceived behavioral control

Choose the correct option based on your perception where 1 stands for strongly disagree and 7 stands for strongly agree.

No.	Items	1	2	3	4	5	6	7
1	It is difficult to use biofertilizer.							
2	Using biofertilizer is within the control of the farmers.							
3	Control of using biofertilizers determines the behavior of the farmers to use biofertilizer.							
4	Farmers are confident about productivity while using biofertilizers.							

Cost–Benefit analysis

Choose the correct option based on your perception where 1 stands for strongly disagree and 7 stands for strongly agree.

No.	Items	1	2	3	4	5	6	7
1	The cost of biofertilizers is low as compared to chemical-based fertilizers.							
2	Using biofertilizers exceeds benefits compared to the cost of low productivity.							
3	The use of biofertilizer reduces yield; hence, benefits exceed cost.							
4	The benefit of biofertilizers for land fertility exceeds the costs of reduced productivity.							

Risk perception

Choose the correct option based on your perception where 1 stands for strongly disagree and 7 stands for strongly agree.

No.	Items	1	2	3	4	5	6	7
1	I think I could easily use bio-fertilizer.							
2	The use of biofertilizers could cause lots of trouble.							
3	The use of biofertilizers would be risky.							
4	There is a high potential for loss if I use biofertilizer.							
5	I think using biofertilizer is highly risky.							

Appendix A.3

Use of biofertilizer for sustainable agriculture

Choose the correct option based on your perception where 1 stands for strongly disagree and 7 stands for strongly agree.

No.	Items	1	2	3	4	5	6	7
1	I expect to use biofertilizer for sustainable agriculture.							
2	I want to use biofertilizer for sustainable agriculture.							
3	I intend to use biofertilizer for sustainable agriculture.							
4	I believe the use of biofertilizer is beneficial for the land.							
5	I believe that the use of biofertilizers is beneficial for getting nutrition in agricultural products.							

Community Development

Choose the correct option based on your perception where 1 stands for strongly disagree and 7 stands for strongly agree.

No.	Items	1	2	3	4	5	6	7
1	More land can be utilized if fertile through biofertilizer.							
2	More price can be charged because of organic crops.							
3	More employment can be generated for processing the biofertilizer.							
4	More income can be generated by utilizing more land for agriculture.							
5	Sustainability can be achieved in agriculture without dependence on chemical-based fertilizer.							

Appendix B Interview Guide

Why do you prefer or do not prefer to use cow dung or camel dung as fertilizer?
Do you use cow dung or camel dung as fertilizer?

Is the use of cow dung or camel dung as fertilizer cost-effective?

Can you compare the use of cow dung or camel dung as fertilizer with chemical-based fertilizers?

What is beneficial for the fertility of soil, cow dung or camel dung as fertilizer or urea?

What are the risks involved in the use of cow dung or camel dung as fertilizer?

What are the perceptual beliefs of farmers towards the use of cow dung or camel dung as fertilizer?

What do you think that the use of cow dung or camel dung as fertilizer is acceptable among farmers?

What do you think is the use of cow dung or camel dung as fertilizer has benefits for obtaining high yield?

مقابلة دليل

كسماد؟ الإبل روث أو البقر روث استخدام تفضل لا أو تفضل لماذا

كسماد؟ الإبل روث أو البقر روث تستخدم هل

التكلفة؟ حيث من فعال كسماد الإبل روث أو البقر روث استخدام هل

الكيميائية؟ الأسمدة مع كسماد الإبل روث أو البقر روث استخدام مقارنة يمكنك هل

يوريا؟ أو كسماد الإبل روث أو البقر روث التربة لخصوبة المفيد هو ما

كسماد؟ الإبل روث أو البقر روث استخدام عليها ينطوي التي المخاطر هي ما

كسماد؟ الإبل روث أو البقر روث استخدام تجاه للمزارعين الإدراكية المعتقدات هي ما

المزارعين؟ بين مقبول كسماد الإبل روث أو البقر روث استخدام في رأيك ما

عالية؟ إنتاجية على للحصول فوائد له كسماد الإبل روث أو البقر روث استخدام في رأيك ما

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