Polyculture Pond Business Development Strategy in Cantigi Sub-District, Indramayu Regency, West Java

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Publication Date: 2025/02/19

Abstract: Fishery commodities are one of the commodities that are abundantly available and have prospects for development. The development of fishery commodities can be done through polyculture ponds in Indramayu Regency with ecological and geographical conditions that support the development of these businesses. Some fishery commodities that have the potential to be developed include milkfish and whiteleg shrimp. The development of polyculture ponds of milkfish, whiteleg shrimp, and tiger shrimp is in line with the National Medium-Term Development Plan (RPJMN) 2020-2024 and the RPJMD (Regional Medium-Term Development Plan) of Indramayu Regency 2021-2026. However, the development of fishery commodities through polyculture ponds has not fully run optimally. This happens due to the decline in productivity of milkfish and whiteleg shrimp as polyculture commodities that are cultivated. This research was conducted using a descriptive quantitative-qualitative method by using direct observation techniques, distributing questionnaires to respondents, and literature studies. The two-way MANOVA (Multivariate Analysis of Variance) test was conducted to determine the difference in influence between milkfish productivity, whiteleg shrimp productivity, and profit as dependent variables on technical cultivation factors and human resource factors as independent variables. Based on the results, it was found that technical cultivation factors and human resource factors simultaneously had a significant effect on milkfish productivity, whiteleg shrimp productivity, and profitability of polyculture ponds. Partially, technical cultivation factors also have a significant effect on milkfish productivity, whiteleg shrimp productivity, and profitability of polyculture ponds. However, human resource factors had an insignificant effect on milkfish productivity, whiteleg shrimp productivity and polyculture farm profits.

Keywords: *Pond Polyculture, Two-Way MANOVA, Technical Cultivation Factors, Human Resource Factors.*

How to Cite: Gabriel Toen Toen Sahat Tua Situngkir; Wawan Gunawan; Sofiatin. (2024). Polyculture Pond Business Development Strategy in Cantigi Sub-District, Indramayu Regency, West Java. *International Journal of Innovative Science and Research Technology*, 9(8), 2939-2950. https://doi.org/10.5281/zenodo.14890837.

I. INTRODUCTION

Fishery commodities are one of the food commodities that have experienced a high increase in trade. This commodity is abundantly available so that it can be used as a community business in utilizing aquatic resources, both freshwater, brackish water, and sea water. In general, one of the efforts that support increased trade in fisheries commodities in Indonesia is through aquaculture. This is because the opening of land used as ponds is able to produce fishery commodities that are quite significant [3]. Land that is opened and used as aquaculture ponds also has promising prospects. This promising prospect of aquaculture ponds can be seen from the natural conditions of Indonesia which have physiographic diversity so as to generate profits for aqua culturists [11].

Some fishery commodities from aquaculture ponds have the potential and prospects to be developed, both for national trade scale and international trade or export scale. The potential and prospects of fishery commodity cultivation through aquaculture is promising enough to improve the standard of living of the people around the pond culture. One of the fishery commodities from aquaculture ponds that have the potential to be developed is milkfish and whiteleg shrimp. According to the Director General of Aquaculture, milkfish and whiteleg shrimp are one of the aquaculture options that have the potential to be developed. This commodity has promising market opportunities with the support of its stable sales price and even tends to increase as well as the high demand of domestic and export markets [15]. In addition to high potential and prospects, the development of milkfish aquaculture is also in line with the National Medium-Term Development Plan (RPJMN) 2020-2024. One of the aquaculture targets in the RPJMN 2020-2024 is to

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

revitalize ponds in shrimp and milkfish production centers to increase fish farming production by 8.5% per year [10].

Indramayu Regency is one of several regencies in West Java that play a role in producing milkfish. Ecologically and geographically, Indramayu Regency is located on the north coast of Java Island and directly adjacent to the Java Sea. This condition is favorable for the people of Indramayu Regency to develop milkfish aquaculture business. Aquaculture itself is one type of cultivation that is quite developed and potential in Indramayu. The cultivation of milkfish ponds utilizes brackish waters through tides. Some of the advantages of milkfish cultivation through ponds, namely the requirements of milkfish cultivation do not require high environmental condition criteria so that it has a high tolerance to changes in environmental conditions and cultivation and hatchery technology that has developed and is quite mastered by some farmers [8]. Indramayu Regency has also been designated by the Ministry of Maritime Affairs and Fisheries to be a minapolitan development location based on the Decree of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia Number KEP. 32/MEN/2010 on the Determination of Minapolitan Areas. When compared to other districts/cities in West Java Province, Indramayu Regency is the district/city with the highest total milkfish production from 2018 to 2020 in West Java. According to data obtained from the West Java Province Maritime and Fisheries Service, the total milkfish production in Indramayu Regency in 2018 was 97,835.54 tons. The total land area used as milkfish ponds in Indramayu Regency amounted to 22,626 ha and became the largest milkfish pond land area in West Java [6].

In addition, the ecological and geographical conditions that are an advantage in Indramayu Regency support coastal communities to conduct polyculture ponds of whiteleg shrimp, tiger shrimp and seaweed. In addition to increasing income from sales, the advantage of polyculture is that the presence of seaweed can increase the oxygen content in the pond water used. This is because seaweed performs photosynthesis during the day which can produce oxygen. The increase in oxygen in pond water causes the formation of coagulants in mud particles and the oxidation of iron in the water. This can make pond water becomes clear. Oxygen production produced by seaweed can also convert toxic ammonia into a food source that can be absorbed into fertilizer by seaweed so that ammonia concentrations in pond water will decrease [12]. Meanwhile, the presence of milkfish cultivated in polyculture is a biosecurity that is herbivorous and able to eat weeds such as moss. The rapid growth of moss can be minimized through milkfish polyculture in the same pond [12]. Milkfish and shrimp cultivated in polyculture in the same pond with seaweed will excrete feces as a result of metabolism. The feces are used as a food source by seaweed. In addition, the activity of milkfish that move in search of food to the bottom of the pond can control algae and plankton that grow on seaweed. This can minimize the occurrence of blooming in the cultivation ponds used [5].

However, the process of polyculture cultivation in Indramayu does not run smoothly. Although Indramayu Regency has the largest pond area and the highest milkfish production in West Java, milkfish production in 2019 and 2020 has decreased by 19.16% [7]. Milkfish, which is a leading commodity in Cantigi Sub-district, Indramayu Regency, West Java, has the lowest percentage of achievement compared to other commodities such as whiteleg shrimp, tiger shrimp, seaweed, tilapia, and other commodities. This indicates that there are several obstacles that can cause the production rate of milkfish not to reach the initial realization determined even though milkfish is the main commodity in aquaculture through ponds in Cantigi Sub-district, Indramayu Regency, West Java.

The decrease in total production and productivity of milkfish and whiteleg shrimp farmed through ponds is caused by technical factors applied by polyculture pond farmers. Most of the polyculture pond farmers in Cantigi Sub-district, Indramayu Regency, West Java still apply traditional cultivation techniques and seem to be less responsive to the use of aquaculture technology [14]. The cultivation process is carried out traditionally because the polyculture pond farmers do cultivation for generations. The lack of use of cultivation technology by polyculture pond farmers themselves is due to capital requirements related to the high price of feed and probiotics (about 60% of the total cost), causing polyculture pond profits obtained can only be used to conduct the next cycle of cultivation. In addition, most polyculture pond farmers in Cantigi Sub-district, Indramayu Regency, West Java also find it difficult to access appropriate, feasible and fast capital loans [9]. This is due to the absence of loan funds provided by the Ministry of Maritime Affairs and Fisheries and the Indramayu Regency Maritime Affairs and Fisheries Office and only some small farmers can borrow money from banks. The application of traditional cultivation techniques by polyculture pond farmers has an impact on the relatively long time in the process of milkfish cultivation and the difficulty of breeding cultured milkfish.

The decrease in total production and productivity of milkfish and whiteleg shrimp farmed through ponds is also caused by unskilled human resources. The lack of skill of human resource factors in the environment of polyculture pond farmers can be seen from the presence of farmers who do not drain pond water and dredge ponds after harvesting so that they have the potential to cause illness in milkfish, the presence of farmers who use used water from shrimp cultivation for milkfish cultivation, and the lack of knowledge of farmers related to recommended cultivation techniques (CBIB/Good Fish Cultivation Practices) [9]. The minimal skill level of the human resource factor in the polyculture pond farmers' environment has an impact on the lack of knowledge related to the handling of diseases that attack polyculture commodities. This correlates with the lack of risk management related to the prevention and resolution of disease problems against milkfish and shrimp farmed. The lack of risk management related to the prevention of disease problems of polyculture commodities

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

can be seen based on the attack of various types of diseases on cultivated polyculture commodities [12].

Therefore, this study was conducted to determine the differences in influence between milkfish productivity, whiteleg shrimp productivity, and profit as dependent variables on technical factors of cultivation and human resource factors as independent variables. Considering that fisheries commodities in Indonesia (especially brackish water fisheries in the form of milkfish) are commodities with potential and development prospects that are convincing enough to improve the welfare of pond managers and communities in Cantigi Sub-district, Indramayu Regency, West Java.

II. METHODS

This research uses descriptive research methods with a mixed method approach (qualitative and quantitative) which aims to obtain information, explanations, and conditions related to the object of research. The data used in this study are primary data obtained from polyculture pond farmers in Cantigi Sub-district, Indramayu Regency, West Java. Two-way MANOVA was used to determine the significance of the effect of several independent variables (nonmetric) based on three types of dependent variables (metric). The variables and their operationalization used can be seen in Table 1.

Table 1: Variables and Variable Measurement Methods in the Study of Polyculture Pond Business Development Strategies in Cantigi Sub-District, Indramayu Regency, West Java

Type of Variable	Measurement Variables and Variable Operationalization	Measurement Variable Method
Dependent variable: 1. Milkfish productivity (kilograms/ha/year) 2. Whiteleg shrimp productivity (kilograms/ha/year) 3. Polyculture pond profit (Rp/year)	Milkfish productivity (kilograms/ha/year) is the amount of milkfish production weight harvested after 6 months in a certain pond area measured in kilograms/ha/year	Based on data obtained from polyculture pond farmers as respondents
	Whiteleg shrimp productivity (kilograms/ha/year) is the total weight of milkfish production harvested after 3 months in a certain area of pond land measured in kilograms/ha/year	Based on data obtained from polyculture pond farmers as respondents
	The profit of polyculture ponds (Rp/year) is the amount of net income earned by farmers through the sale of milkfish by reducing the total costs required against the total gross income earned.	π = TR – TC TR = Total Revenue (Price x Quantity) TC = Total Cost (Fixed Cost + Variable Cost)
Independent variable: 1. Technical cultivation factors 2. Human resource factors	The technical factor of aquaculture is an effort to meet the needs of aquaculture ponds so as to achieve production targets. Intensive cultivation has a high stocking density (15-40 heads/m^2), already using waterwheels, and already has an organized feeding program, semi-intensive cultivation has a lower stocking density compared to intensive cultivation techniques (3-10 heads/m^2) and the presence of artificial feed with a limited quantity, and traditional cultivation has a low stocking density (0.1-1 heads/m^2).	Level 1: Intensive cultivation Level 2: Semi-intensive cultivation Level 3: Traditional cultivation
	The human resource factor is a factor consisting of people with readiness, willingness, and ability to contribute to the success of a business goal. Human resources skilled in aquaculture ponds are characterized by the level of education carried out by farmers more than 9 years; cultivation experience more than equal to 17 years; the age of farmers who are smaller than equal to 42 years; the ability to manage water and sanitation (dredging ponds and replacing pond water is done after harvest regularly); and the ability to manage irrigation and feed systems (feeding in accordance with the needs of milkfish). Less skilled human resources in aquaculture cultivation are characterized by less than 9 years of education; less than 17 years of cultivation experience; greater than 42 years of age; inability to manage water and sanitation (no dredging of ponds and replacement of pond water after regular harvest); and inability to manage watering and feeding systems (feeding less/more than the needs of milkfish).	Level 1: Skilled Level 2: Less skilled

Source: [2], [4], [1], [13]

There are assumed to be k independent random samples of size n in the multivariate case obtained from p normal populations with the same covariance matrix, which is equivalent to the following design for balanced two-way MANOVA. In practice, y_{ij} representing the observation vector can be written sequentially and sample 2 will appear under sample 1, and so on as shown in Table 2.

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

Table 2: MANOVA General Model

Sample 1 From N_p (μ_1, Σ)	**Sample 2 From N_p (μ_2, Σ)**	**…**	**Sample 1 From N_p (μ_k, Σ)**
Y_{11}	Y_{21}	…	Y_{k1}
y_{12}	Y_{22}	…	Y_{k2}
.	.	…	.
.	.	…	.
Y_{1n}	y_{2n}	…	.
Total Y_1	Y_2	…	Y_k
Mean Y_1	Y_2	…	Y_k

The total sample used in the proposed MANOVA model can be seen in the following formula.

Total of i^{th} sample yi = $\sum_i^k \sum_{j=1}^n yij$ (1)

Overall total Y.. = $\sum_{j=1}^n Yij$ (2)

Mean of i^{th} sample $\hat{Y}i = \ddot{Y}i/n$ (3)

verall mean $\hat{Y}_{..} = Y_{..}/kn$ (4)

So that the proposed general MANOVA model can be formed as follows.

$Y_1, Y_2, Y_3 = A + \alpha_1 X_1 + \alpha_2 X_2 + cX_1X_2$ (5)

Through Equation 1, Equation 2 can be formed as follows.

$$\begin{pmatrix} Yij1 \\ Yij2 \\ Yij3 \end{pmatrix} = \begin{pmatrix} A1 \\ A2 \\ A3 \end{pmatrix} + \begin{pmatrix} \alpha i1 \\ \alpha i2 \\ \alpha i3 \end{pmatrix} + \begin{pmatrix} \alpha ij1 \\ \alpha ij2 \\ \alpha ij3 \end{pmatrix} + \begin{pmatrix} c1 \\ c2 \\ c3 \end{pmatrix} \quad (6)$$

For a balanced data with a two-way model, the "total sum of squares and products matrix" can be partitioned as follows.

$T = H_A + H_B + H_{AB} + E$ (7)

The structure of one of the hypothesis matrices is similar to H, so H has the following form:

$$H_A, H_B, H_{AB} = \begin{pmatrix} SSH11 & SSH21 & SSH31 \\ \vdots & \ddots & \vdots \\ SSHA1p & SSHA12 & SSHArr \end{pmatrix} \quad (8)$$

For example, "HA has the sum of squares on the diagonal for factor A for each of the p variables. The off-diagonal elements of HA are the sum of the products corresponding to all pairs of variables. Thus, the r^{th} diagonal element of H_A corresponding to the r^{th} variable, r = 1, 2, ..., p, is as follows.

$$hA_{rr} = nb \sum_{i=1}^{a} (\hat{y}i.r - \hat{y}..r)^2 = \sum_{i=1}^{a} \frac{(yi.r)^2}{nb} - \frac{(y..r)^2}{nab} \quad (9)$$

$y_{i.r}$ and $y_{..r}$ are respectively the r^{th} components of $y_{i.}$ and $y_{...}$, where $y_{i.r}$ and $y_{..r}$ represent the totals for the r^{th} component. Thus, the $(rs)^{th}$ off-diagonal element of H_A is as follows.

$$hA_{rs} = nb \sum_{i=1}^{a} (\hat{y}i.r - \hat{y}..r)^2 = \sum_{i=1}^{a} \frac{(yi.r)(y..r)}{nb} - \frac{(y..r)^2}{nab} \quad (10)$$

Based on Table 2 and Equation (7), we obtain the r^{th} diagonal element of H_{AB} corresponding to the r^{th} variable, r = 1, 2, …, p, is as follows.

$$hAB_{rr} = \sum_{i\,j} \frac{(yij.r)^2}{n} + \frac{(y..r)^2}{nab} - hArr - hBrr \quad (11)$$

$$hAB_{rs} = \sum_{i\,j} \frac{yij.s - y..s}{n} + \frac{y..r - y..s}{nab} - hArs - hBrs \quad (12)$$

Table 3: Two-Way MANOVA Matrix

Variance Source	**Sum of Square and Products Matrix**	**Degrees of Freedom**
Factor 1	$H_A = nb \sum_i^a (\hat{y}_{i...} - \hat{y}_{...})(\hat{y}_{i...} - \hat{y}_{...})'$	a-1
Factor 2	$H_B = na \sum_i^b (\hat{y}_{.j.} - \hat{y}_{...})(\hat{y}_{.j.} - \hat{y}_{...})'$	b-1
Interaction of factor 1 and factor 2	$H_{AB} = n \sum_{ij}^b (\hat{y}_{ij.} - \hat{y}_{i..} - \hat{y}_{.j.} + \hat{y}_{...})(\hat{y}_{ij.} - \hat{y}_{i..} - \hat{y}_{.j.} + \hat{y}_{...})'$	(a-1)(b-1)
Error	$E = \sum_{ijk}^{abn} (\hat{y}_{ijk} - \hat{y}_{ij.})(\hat{y}_{ijk} - \hat{y}_{ij})'$	ab(n – 1)
Total	$T = \sum_{ijk}^{abn} (\hat{y}_{ijk} - \hat{y})(\hat{y}_{ijk} - \hat{y}_{...})'$	abn – 1

The element of E would be expressed as follows.

$$e_{rr} = \sum_{i\,j} (y^2_{ij.kr}) - \frac{(y..r)^2}{nab} - hA_{rr} - hB_{rr} - hAB_{rr} \quad (13)$$

$$e_{rs} = \sum_{i\,j} (y_{ij\cdot kr})(y_{ij\cdot ks}) - \frac{(y..r)(y..s)}{nab} - hA_{rs} - hB_{rs} - hAB_{rs} \quad (14)$$

After the residual matrix (E) is known in Equation 13 and Equation 14, the next step is to calculate the lambda value (λ) for factor 1, factor 2, as well as the interaction between factor 1 and factor 2. The formula that can be used to find the lambda value for factor 1, factor 2, as well as the interaction between factor 1 and factor 2 can be seen as follows.

$$\lambda_1 = \left(\frac{|E|}{|E+HA|}\right) \tag{15}$$

$$\lambda_2 = \left(\frac{|E|}{|E+HB|}\right) \tag{16}$$

$$\lambda_{12} = \left(\frac{|E|}{|E+HAB|}\right) \tag{17}$$

After knowing the lambda value of factor 1, factor 2, as well as the interaction of factor 1 and factor 2; then the calculation for the F value (F_{Count}) can be done which will be compared with the F value in the Wilks' Lambda table (F_{Table}). The calculation for the F value of factor 1 (F_{X1}), the F value of factor 2 (F_{X2}), and the F value of the interaction between factor 1 and factor 2 (F_{X1X2}) can be done using the following formula.

$$F_{X1} = \left(\frac{1-\lambda 1}{\lambda 1}\right) x \left(\frac{\left(\frac{ab(n-1)-p+1}{2}\right)}{\left(\frac{|(a-1)-p|+1}{2}\right)}\right) \tag{18}$$

$$F_{X2} = \left(\frac{1-\lambda 2}{\lambda 2}\right) x \left(\frac{\left(\frac{ab(n-1)-p+1}{2}\right)}{\left(\frac{|(b-1)-p|+1}{2}\right)}\right) \tag{19}$$

$$F_{X1X2} = \left(\frac{1-\lambda 12}{\lambda 12}\right) x \left(\frac{\left(\frac{ab(n-1)-p+1}{2}\right)}{\left(\frac{|(a-1)(b-1)-p|+1}{2}\right)}\right) \tag{20}$$

After calculating the F value of factor 1 (F_{X1}), the F value of factor 2 (F_{X2}), as well as the F value of the interaction between factor 1 and factor 2 (F_{X1X2}); then a decision can be made to accept H_0 or reject H_0 by comparing the calculated F value of each factor with the F value in the Wilks' Lambda table. The decision criteria that can be used to determine the acceptance or rejection of H_0 can be seen as follows.

If: $F_{Count} < F_{Table}$, then accept H_0

If: $F_{Count} > F_{Table}$, then reject H_0 and accept H_1

III. RESULT AND DISCUSSION

Data were obtained from polyculture pond farmers in Cantigi Sub-District, Indramayu Regency, West Java related to milkfish productivity, whiteleg shrimp productivity, and polyculture pond profits as independent variables. Meanwhile, data as dependent variables obtained were in the form of technical cultivation factors and human resource factors. There are three levels (categories) in measuring technical cultivation factors and two levels (categories) in measuring human resource factors respectively, namely (1) intensive cultivation, (2) semi-intensive cultivation, and (3) traditional cultivation; (1) skilled and (2) less skilled as stated in Table 4.

Table 4: Technical Cultivation Factor and Human Resource Factor Categories

Factor		Frequency	Percentage (%)
Technical cultivation factor	Human resource factor		
Intensive cultivation ($X_1 = 1$)	Skilled ($X_2 = 1$)	-	0
	Less skilled ($X_2 = 2$)	-	0
Semi-intensive cultivation ($X_1 = 2$)	Skilled ($X_2 = 1$)	1	2.86
	Less skilled ($X_2 = 2$)	11	31.43
Traditional cultivation ($X_1 = 3$)	Skilled ($X_2 = 1$)	3	8.57
	Less skilled ($X_2 = 2$)	20	57.14

Two-way classification of milkfish productivity (Y_1; kilograms/ha/year), whiteleg shrimp productivity (Y_2; kilograms/ha/year), and polyculture pond profits (Y_3; Rp/year) as independent variables and technical factors of cultivation and human resource factors as dependent variables are summarized in Table 5. Measurements were made on the combination of independent variables on the dependent variable using a category scale for 35 observations in Table 5.

Table 5: Two-Way Classification of Measurements for Polyculture Pond Farmers

Categories		Technical Cultivation Factors					
		$X_1 = 2$			$X_1 = 3$		
		Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
Human Resource Factors	$X_2 = 1$	2,000	60	Rp225,069,000.00	1,200	720	Rp112,020,000.00
					1,67	500	Rp111,600,000.00
					2,500	1200	Rp155,700,000.00
	$X_2 = 2$	1,360	600	Rp69,834,501.20	700	540	Rp207,885,000.00
		1,000	150	Rp136,234,246,58	1,160	672	Rp102,400,000.00
		1,200	200	Rp128,580,246,58	1,280	840	Rp107,300,000.00
		1,500	300	Rp113,880,246.58	1,600	480	Rp65,400,000.00
		1,142.86	171.43	Rp138,880,246.58	2,240	600	Rp185,000,000.00

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

		1,333.33	200	Rp120,880,246.58	1,680	720	Rp105,300,000.00
		1,600	240	Rp138,880,246.58	3,000	1,200	Rp181,200,000.00
		1,500	300	Rp94,680.58	1,533.33	600	Rp116,600,000.00
		1,400	240	Rp105,680,246.58	220	1,050	Rp130,480,000.00
		1,280	240	Rp99,080,246.58	250	900	Rp123,480,000.00
		3,000	2,100	Rp278,600,000.00	1,600	600	Rp122,250,000.00
					1,333.33	800	Rp128,500,000.00
					1,600	840	Rp118,800,000.00
					2,300	1,050	Rp129,100,000.00
					2,300	1,350	Rp158,880,000.00
					2,000	1,080	Rp167,900,000.00
					1,600	960	Rp133,500,000.00
					1,333.33	900	Rp149,200,000.00
					1,800	1,200	Rp119,500,000.00
					1,166.67	800	Rp117,400,000.00

After grouping and summing based on the groups $X_1 = 2$ and $X_2 = 1$; $X_1 = 3$ and $X_2 = 1$; $X_2 = 2$ and $X_3 = 2$; as well as $X_1 = 3$ and $X_2 = 2$, a vertical and horizontal calculation will be carried out separately for the variables of milkfish productivity, whiteleg shrimp productivity, and polyculture pond profits. The sums for each variable can be found in Table 6, Table 7 and Table 8.

Table 6: The Summation of Milkfish Productivity (Kilograms/Ha/Year) from Respondents based on Groups of Technical Cultivation Factors and Human Resource Factors

Categories	**$X_1 = 2$**	**$X_1 = 3$**	**Total**
$X_2 = 1$	2,000	5,367	7,367
$X_2 = 2$	16,319.19	30,696,666	47,012.86
Total	18,316.19	36,063,666	54,379.86

Table 7: The Summation of Whiteleg Shrimp Productivity (Kilograms/Ha/Year) of Respondents based on Groups of Technical Cultivation Factors and Human Resource Factors

Categories	**$X_1 = 2$**	**$X_1 = 3$**	**Total**
$X_2 = 1$	60	2,420	2,480
$X_2 = 2$	4,741.43	17,182	21,923.43
Total	4,801.43	19,602	24,403.43

Table 8: The Summation of Polyculture Ponds Profit (Rp/Year) of Respondents Based on Groups of Technical Cultivation Factors and Human Resource Factors

Categories	**$X_1 = 2$**	**$X_1 = 3$**	**Total**
$X_2 = 1$	225,069,000	379,320,000	604,389,000
$X_2 = 2$	1.224,944,907.84	2,670,075,000	3,895,019,907.84
Total	1.450,013,907.84	3,049,395,000	4,499,408,907.84

After calculating the vertical and horizontal totals for the variables of milkfish productivity, whiteleg shrimp productivity, and polyculture pond profits, a regrouping was conducted based on the total amount vertically as factor 1 and horizontally as factor 2 for the variables used. The results of the grouping for factor 1 and factor 2 can be seen in Table 9 and Table 10.

Table 9: Grouping the Total Vertical Amount as Factor 1 for the Milkfish Productivity (Y_1), Whiteleg Shrimp Productivity (Y_2), and Polyculture Pond Profits (Y_3)

Y_1	**Y_2**	**Y_3**
7,367.00	2,480.00	604,389,000.00
47,012.86	21,923.43	3,895,019,907.84
54,379.86	24,403.43	4,499,408,907.84

Table 10: Grouping the Total Horizontal Amount as a Factor of 2 for the Milkfish Productivity (Y_1), Whiteleg Shrimp Productivity (Y_2), and Polyculture Pond Profits (Y_3)

Y_1	**Y_2**	**Y_3**
18,316.19	4,801.43	1,450,013,907.84
36,063.67	19,602.00	3,049,395,000.00

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

54,379.86	24,403.43	4,499,408,907.84

After grouping each variable as factor 1 and factor 2, the calculation of matrix H for factor 1 and factor 2 will be performed using the formula shown in Equation 9. It is known that the degrees of freedom for factor 1 (a-1) is 1 and the degrees of freedom for factor 2 (b-1) is 1. The (1, 1); (2, 2); and (3, 3) element of H_A (corresponding to Table 9) is given as follows.

$$hA_{11} = \frac{(7{,}367)^2+(47{,}012.86)^2}{(3)(3)} - \frac{(54{,}379.86)^2}{(3)(1)(3)} = -76{,}965{,}268.9$$

$$hA_{22} = \frac{(2{,}480)^2+(21{,}923.43)^2}{(3)(3)} - \frac{(24{,}403.43)^2}{(3)(1)(3)} = -12{,}082{,}245.32$$

$$hA_{33} = \frac{(604{,}389{,}000)^2+(3{,}895{,}019{,}907.84)^2}{(3)(3)} - \frac{(4{,}499{,}408{,}907.84)^2}{(3)(1)(3)} = -5.23134930462113E+17$$

Using computational forms in Equation 10, the (1, 2); (1, 3); (2, 1); (2, 3); (3, 1); and (3, 2) element of HA (corresponding to Table 9) is given as follows.

$$hA_{12} = \frac{(7{,}367)(2{,}480)+(47{,}012.86)(21{,}923.43)}{(3)(1)} - \frac{(54{,}379.86)(24{,}403.43)}{(3)(1)(3)} = -1.46600560358889E+07$$

$$hA_{13} = \frac{(7{,}367)(604{,}389{,}000)+(47{,}012.86)(3{,}895{,}019{,}907.84)}{(3)(1)} - \frac{(54{,}379.86)(4{,}499{,}408{,}907.84)}{(3)(1)(3)} = -2.38759939800459E+12$$

$$hA_{21} = \frac{(2{,}480)(7{,}367)+(21{,}923.43)(47{,}012.86)}{(3)(1)} - \frac{(24{,}403.43)(54{,}379.86)}{(3)(1)(3)} = -1.46600560358889E+07$$

$$hA_{23} = \frac{(2{,}480)(604{,}389{,}000)+(21{,}923.43)(3{,}895{,}019{,}907.84)}{(3)(1)} - \frac{(24{,}403.43)(4{,}499{,}408{,}907.84)}{(3)(1)(3)} = -1.21320566014713E+12$$

$$hA_{31} = \frac{(604{,}389{,}000)(7{,}367)+(3{,}895{,}019{,}907.84)(47{,}012.86)}{(3)(1)} - \frac{(4{,}499{,}408{,}907.84)(54{,}379.86)}{(3)(1)(3)} = -2.38759939800459E+12$$

$$hA_{32} = \frac{(604{,}389{,}000)(2{,}480)+(3{,}895{,}019{,}907.84)(21{,}923.43)}{(3)(1)} - \frac{(4{,}499{,}408{,}907.84)(24{,}403.43}{(3)(1)(3)} = -1.21320566014713E+12$$

Thus, the HA matrix is

$$H_A = \begin{pmatrix} -76{,}965{,}268.9 & -1.46600560358889E+07 & -2.38759939800459E+12 \\ -1.46600560358889E+07 & -12{,}082{,}245.32 & -1.21320566014713E+12 \\ -2.38759939800459E+12 & -1.21320566014713E+12 & -5.23134930462113E+17 \end{pmatrix}$$

Using computational forms in Equation 9 and Equation 10, the (1, 1); (2, 2); (3, 3); (1, 2); (1, 3); (2, 1); (2, 3); (3, 1); and (3, 2) element of H_B (corresponding to Table 10) is given as follows.

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

$$hB_{11} = \frac{(18{,}316.19)^2 + (36{,}063.67)^2}{(3)(3)} - \frac{(54{,}379.96)^2}{(3)(1)(3)} = -146{,}788{,}657.5$$

$$hB_{22} = \frac{(4{,}801.43)^2 + (19{,}602)^2}{(3)(3)} - \frac{(24{,}403.43)^2}{(3)(1)(3)} = -20{,}915{,}024.72$$

$$hB_{33} = \frac{(1{,}450{,}013{,}907.84)^2 + (3{,}049{,}395{,}000)^2}{(3)(3)} - \frac{(4{,}499{,}408{,}907.84)^2}{(3)(1)(3)} = -9.82592E+17$$

$$hB_{12} = \frac{(18{,}316.19)(4{,}801.43) + (36{,}063.67)(19{,}602)}{(3)(1)} - \frac{(54{,}379.86)(24{,}403.43)}{(3)(1)(3)} = 1.90399998361518E+07$$

$$hB_{13} = \frac{(18{,}316.19)(1{,}450{,}013{,}907.84) + (36{,}063.67)(3{,}049{,}395{,}000)}{(3)(1)} - \frac{(54{,}379.86)(4{,}499{,}408{,}907.84)}{(3)(1)(3)} = 1.1591525159597E+13$$

$$hB_{21} = \frac{(4{,}801.43)(18{,}316.19) + (19{,}602)(36{,}063.67)}{(3)(1)} - \frac{(24{,}403.43)(54{,}379.86)}{(3)(1)(3)} = 1.90399998361518E+07$$

$$hB_{23} = \frac{(4{,}801.43)(1{,}450{,}013{,}907.84) + (19{,}602)(3{,}049{,}395{,}000)}{(3)(1)} - \frac{(24{,}403.43)(4{,}499{,}408{,}907.84)}{(3)(1)(3)} = 1.40360937923508E+12$$

$$hB_{31} = \frac{(1{,}450{,}013{,}907.84)(18{,}316.19) + (3{,}049{,}395{,}000)(36{,}063.67)}{(3)(1)} - \frac{(4{,}499{,}408{,}907.84)(54{,}379.86)}{(3)(1)(3)} = 1.1591525159597E+13$$

$$hB_{32} = \frac{(1{,}450{,}013{,}907.84)(4{,}801.43) + (3{,}049{,}395{,}000)(19{,}602)}{(3)(1)} - \frac{(4{,}499{,}408{,}907.84)(24{,}403.43)}{(3)(1)(3)} = 1.40360937923508E+12$$

Thus, the H_B matrix is

$$H_B = \begin{pmatrix} -146{,}788{,}657{,}5 & 1.90399998361518E+07 & 1.1591525159597E+13 \\ 1.90399998361518E+07 & -20{,}915{,}024.72 & 1.40360937923508E+12 \\ 1.1591525159597E+13 & 1.40360937923508E+12 & -9.82592E+17 \end{pmatrix}$$

After calculating the matrix H for factor 1 and factor 2, calculations were also performed on the matrix H for the interaction between factor 1 and factor 2 using the notation hAB with the formula presented in Equation 11 and Equation 12. To calculate the matrix hAB, it is necessary to group the data based on the variables of milkfish productivity (Y_1), whiteleg shrimp productivity (Y_2), and polyculture pond profits (Y_3). The data grouping based on these variables can be seen in Table 11.

Table 11: Data Classification based on the Milkfish Productivity (Y_1), Whiteleg Shrimp Productivity (Y_2), and Polyculture Pond Profits (Y_3)

Y_1		**Y_2**		**Y_3**	
2,000	5,367	60	2,420	225,069,000	379,320,000
16,316.19	30,696.67	4,741.43	17,182	1,224,944,907.84	2,670,075,000

Then, we can obtain the (1, 1); (2, 2); (3, 3); (1, 2); (1, 3); (2, 1); (2, 3); (3, 1); and (3, 2) element of H_{AB} (corresponding to Table 11) is given as follows.

$$hAB_{11} = \frac{(2{,}000)^2 + (5{,}367)^2 + (16{,}316.19)^2 + (30{,}696.67)^2}{3} + \frac{(54{,}379.86)^2}{(3)(1)(3)} - (-76.965.268{,}9) - (-146.788.657{,}5) = 966{,}097{,}580.2$$

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

$$hAB_{22} = = \frac{(60)^2+(2{,}420)^2+(4{,}741.43)^2+(17{,}182)^2}{3} + \frac{(24{,}403.43)^2}{(3)(1)(3)} - (-12.082.245{,}32) - (-20{,}915{,}024.72) = 58{,}516{,}220$$

$$hAB_{33} = \frac{(225{,}069{,}000)^2+(379{,}320{,}000)^2+(1{,}224{,}944{,}907.84)^2+(2{,}670{,}075{,}000)^2}{3} + \frac{(4{,}499{,}408{,}907.84)^2}{(3)(1)(3)} - (-5{,}23134930462113E+17) - (-9.82592E+17)$$

hAB_{33} = 6.69657955168799E+18

$$hAB_{12} = \frac{(2{,}000)(60)+(5{,}367)(2{,}420)+(16{,}316.19)(4{,}741.43)+(30{,}696.67)(1{,}224{,}944{,}907.84)}{3} + \frac{(54{,}379.86)(24{,}403.43)}{(3)(1)(3)} - (-1{,}46600560358889E+07) - (1.90399998361518E+07)$$

hAB_{12} = 3.49037377296265E+08

$$hAB_{13} = \frac{(2{,}000)(225{,}069{,}000)+(5{,}367)(379{,}320{,}000)+(16{,}316.19)(1{,}224{,}944{,}907.84)+(30{,}696.67)(2{,}670{,}075{,}000)}{3} + \frac{(54{,}379.86)(4{,}499{,}408{,}907.84)}{(3)(1)(3)} - (-2{,}38759939800459E+12) - (1.1591525159597E+13)$$

hAB_{13} = 5.27940249929472E+13

$$hAB_{13} = \frac{(2{,}000)(225{,}069{,}000)+(5{,}367)(379{,}320{,}000)+(16{,}316.19)(1{,}224{,}944{,}907.84)+(30{,}696.67)(2{,}670{,}075{,}000)}{3} + \frac{(54{,}379.86)(4{,}499{,}408{,}907.84)}{(3)(1)(3)} - (-2{,}38759939800459E+12) - (1.1591525159597E+13)$$

hAB_{13} = 5.27940249929472E+13

$$hAB_{21} = \frac{(60)(2{,}000)+(2{,}420)(5{,}367)+(4{,}741.43)(16{,}316.19)+(1{,}224{,}944{,}907.84)(30{,}696.67)}{3} + \frac{(24{,}403.43)(54{,}379.86)}{(3)(1)(3)} - (-1{,}46600560358889E+07) - (1.90399998361518E+07)$$

hAB_{21} = 3.49037377296265E+08

$$hAB_{23} = \frac{(60)(225{,}069{,}000)+(2{,}420)(379{,}320{,}000)+(4{,}741.43)(1{,}224{,}944{,}907.84)+(1{,}224{,}944{,}907.84)(2{,}670{,}075{,}000)}{3} + \frac{(24{,}403.43)(4{,}499{,}408{,}907.84)}{(3)(1)(3)} - (-1{,}21320566014713E+12) - (1.40360937923508E+12)$$

hAB_{23} = 2.95486002056616E+13

$$hAB_{31} = \frac{(225{,}069{,}000)(2{,}000)+(379{,}320{,}000)(5{,}367)+(1{,}224{,}944{,}907.84)(16{,}316.19)+(2{,}670{,}075{,}000)(30{,}696.67)}{3} + \frac{(4{,}499{,}408{,}907.84)(54{,}379.86)}{(3)(1)(3)} - (-2{,}38759939800459E+12) - (1.1591525159597E+13)$$

hAB_{31} = 5.27940249929472E+13

$$hAB_{32} = \frac{(225{,}069{,}000)(60)+(379{,}320{,}000)(2{,}420)+(1{,}224{,}944{,}907.84)(4{,}741.43)+(2{,}670{,}075{,}000)(1{,}224{,}944{,}907.84)}{3} + \frac{(4{,}499{,}408{,}907.84)(24{,}403.43)}{(3)(1)(3)} - (-1{,}21320566014713E+12) - (1.40360937923508E+12)$$

hAB_{32} = 2.95486002056616E+13

Thus, the H_{AB} matrix is

$$H_{AB} = \begin{pmatrix} 966{,}097{,}580.2 & 3.49037377296265E+08 & 5.27940249929472E+13 \\ 3.49037377296265E+08 & 58{,}516{,}220 & 2.95486002056616E+13 \\ 5.27940249929472E+13 & 2.95486002056616E+13 & 6.69657955168799E+18 \end{pmatrix}$$

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

After forming the H matrix for the interaction of factor 1 and factor 2, the calculation of the residual matrix (T) will be carried out. Before calculating the residual matrix (T), it is necessary to know the calculation of the matrix (E) using the data in Table 5. The calculation of the matrix (E) at e_{11} with the formula presented in Equation 13 and Equation 14 can be done as follows.

$$e_{11} = ((2{,}000)^2 + (1{,}360)^2 + (1{,}000)^2 + (1{,}200)^2 + (1{,}500)^2 + (1{,}142.86)^2 + (1{,}333.33)^2 + (1{,}600)^2 + (1{,}500)^2 + (1{,}400)^2 + (1{,}280)^2 + (3{,}000)^2 + (1{,}200)^2 + (1{,}667)^2 + (2{,}500)^2 + (700)^2 + (1{,}160)^2 + (1{,}280)^2 + (1{,}600)^2 + (2{,}240)^2 + (1{,}680)^2 + (3{,}000)^2 + (1{,}533.33)^2 + (220)^2 + (250)^2 + (1{,}600)^2 + (1{,}333.33)^2 + (1{,}600)^2 + (2{,}300)^2 + (2{,}300)^2 + (2{,}000)^2 + (1{,}600)^2 + (1{,}333.33)^2 + (1{,}800)^2 + (1{,}166.67)^2 - (\frac{54{,}379.86^2}{(3)(1)(3)}) - (-76{,}965{,}268.9) - (-146{,}788{,}657.5) - (966{,}097{,}580.2)$$

$e_{11} = -973{,}664{,}494.4$

Using the same equation (Equation 13), we can obtain the value of e_{22} and e_{33} as follows.

$e_{22} = -216{,}848{,}129.5$
$e_{33} = -6.75831E+18$

$$e_{12} = (2{,}000)(60) + (1{,}360)(600) + (1{,}000)(150) + (1{,}200)(200) + (1{,}500)(300) + (1{,}142.86)(171.43) + (1{,}333.33)(200) + (1{,}600)(240) + (1{,}500)(300) + (1{,}400)(240) + (1{,}280)(240) + (3{,}000)(2{,}100) + (1{,}200)(720) + (1{,}667)(500) + (2{,}500)(1{,}200) + (700)(540) + (1{,}160)(672) + (1{,}280)(840) + (1{,}600)(480) + (2{,}240)(600) + (1{,}680)(720) + (3{,}000)(1{,}200) + (1{,}533.33)(600) + (220)(1{,}050) + (250)(900) + (1{,}600)(600) + (1{,}333.33)(800) + (1{,}600)(840) + (2{,}300)(1{,}050) - \left(\frac{(54{,}379.86)(24{,}403.43)}{(3)(1)(3)}\right) - (-1{,}46600560358889E+07) - (1.90399998361518E+07) - (3.49037377296265E+08)$$

$e_{12} = -1.63835E+09$

Using the same equation (Equation 14), we can obtain the value of e_{13}, e_{21}, e_{23}, e_{31}, and e_{32} as follows.

$e_{13} = -2.99107E+14$
$e_{21} = -1.63835E+09$
$e_{23} = -1.36033E+14$
$e_{31} = -2.99107E+14$
$e_{32} = -1.36033E+14$

Thus, the matrix E is

$$E = \begin{pmatrix} -973{,}664{,}494.4 & -1.63835E+09 & -2.99107E+14 \\ -1.63835E+09 & -216{,}848{,}129.5 & -1.36033E+14 \\ -2.99107E+14 & -1.36033E+14 & -6.75831E+18 \end{pmatrix}$$

After the total H matrix (E) is formed, the calculation of the residual matrix (T) will be carried out. The calculation is done using the formula in Equation 7 as follows.

$$\text{Residual matrix (T)} = \begin{pmatrix} -973.664.494{,}4 & -1.63835E+09 & -2.99107E+14 \\ -1.63835E+09 & -216{,}848{,}129.5 & -1.36033E+14 \\ -2.99107E+14 & -1.36033E+14 & -6.75831E+18 \end{pmatrix} - \begin{pmatrix} -76.965.268{,}9 & -1{,}46600560358889E+07 & -2{,}38759939800459E+12 \\ -1{,}46600560358889E+07 & -12.082.245{,}32 & -1{,}21320566014713E+12 \\ -2{,}38759939800459E+12 & -1{,}21320566014713E+12 & -5{,}23134930462113E+17 \end{pmatrix} - \begin{pmatrix} -146.788.657{,}5 & 1{,}90399998361518E+07 & 1{,}1591525159597E+13 \\ 1{,}90399998361518E+07 & -20.915.024{,}72 & 1{,}40360937923508E+12 \\ 1{,}1591525159597E+13 & 1{,}40360937923508E+12 & -9{,}82592E+17 \end{pmatrix} \begin{pmatrix} 966.097.580{,}2 & 3{,}49037377296265E+08 & 5{,}27940249929472E+13 \\ 3{,}49037377296265E+08 & 58.516.220 & 2{,}95486002056616E+13 \\ 5{,}27940249929472E+13 & 2{,}95486002056616E+13 & 6{,}69657955168799E+18 \end{pmatrix}$$

$$\text{Residual matrix (T)} = \begin{pmatrix} -2.8903E+31 & -1.3478E+09 & -2.5394E+14 \\ -1.3478E+09 & -1.3993E+26 & -1.1182E+14 \\ -2.5394E+14 & -1.1182E+14 & -1.5675E+18 \end{pmatrix}$$

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

Table 12: Summary of MANOVA

Variance Source	Sum of Square and Products Matrix	Degrees of Freedom
Factor 1	$H_A = \begin{pmatrix} -76{,}965{,}268.9 & -1.46600560358889E+07 & -2.38759939800459E+12 \\ -1.46600560358889E+07 & -12{,}082{,}245.32 & -1.21320566014713E+12 \\ -2.38759939800459E+12 & -1.21320566014713E+12 & -5.23134930462113E+17 \end{pmatrix}$	0
Factor 2	$H_B = \begin{pmatrix} -146{,}788{,}657.5 & 1.90399998361518E+07 & 1.1591525159597E+13 \\ 1.90399998361518E+07 & -20{,}915{,}024.72 & 1.40360937923508E+12 \\ 1.1591525159597E+13 & 1.40360937923508E+12 & -9.82592E+17 \end{pmatrix}$	0
Interaction of factor 1 and factor 2	$H_{AB} = \begin{pmatrix} 966{,}097{,}580.2 & 3.49037377296265E+08 & 5.27940249929472E+13 \\ 3.49037377296265E+08 & 58{,}516{,}220 & 2.95486002056616E+13 \\ 5.27940249929472E+13 & 2.95486002056616E+13 & 6.69657955168799E+18 \end{pmatrix}$	1
Error	$E = \begin{pmatrix} -973{,}664{,}494.4 & -1.63835E+09 & -2.99107E+14 \\ -1.63835E+09 & -216{,}848{,}129.5 & -1.36033E+14 \\ -2.99107E+14 & -1.36033E+14 & -6.75831E+18 \end{pmatrix}$	31
Total	$T == \begin{pmatrix} -2.8903E+31 & -1.3478E+09 & -2.5394E+14 \\ -1.3478E+09 & -1.3993E+26 & -1.1182E+14 \\ -2.5394E+14 & -1.1182E+14 & -1.5675E+18 \end{pmatrix}$	35

After knowing the residual matrix (T) above, the next calculation will be carried out on the Lambda value (λ) of factor 1, factor 2, and the interaction between factor 1 and factor 2. λ_1 is used to determine the main impact of factor 1 through Wilks' Lambda, λ_2 is used to determine the main impact of factor 2 through Wilks' Lambda, and λ_{12} is used to determine the main effect of the interaction between factor 1 and factor 2 through Wilks' Lambda. The formula that can be used to find the lambda value of factor 1, factor 2, and the interaction between factor 1 and factor 2 can be seen in Equation 15, Equation 16, and Equation 17. To test the main impact of factor 1 with Wilks' Lambda, we have

$$\lambda_1 = \left(\frac{3{,}72425E+75}{1{,}60855E+75}\right) = 2.3153E+00$$

$$\lambda_2 = \left(\frac{3{,}72425E+75}{-2{,}49625E+74}\right) = -1.4919E+01$$

$$\lambda_{12} = \left(\frac{3{,}72425E+75}{-6{,}7531E+37}\right) = -5.5149E+37$$

After knowing the lambda value of factor 1, factor 2, and the interaction of factor 1 and factor 2; then the calculation can be done for the F value (F_{Count}) which will be compared with the F value in the Wilks' Lambda table. The calculation for the F value of factor 1 (F_{X1}), the F value of factor 2 (F_{X2}), and the interaction F value between factor 1 and factor 2 (F_{X1X2}) can be done using Equation 18, Equation 19, and Equation 20.

$$F_{X1} = \left(\frac{1-2.3153E+00}{2.3153E+00}\right)\left(\frac{\left(\frac{31-3+1}{2}\right)}{\left(\frac{|0-3|+1}{2}\right)}\right) = -4.1186E+00$$

$$F_{X2} = \left(\frac{1-(-1.4919E+01)}{-1.4919E+01}\right) x \left(\frac{\left(\frac{31-3+1}{2}\right)}{\left(\frac{|0-3|+1}{2}\right)}\right) = -7.7359E+00$$

$$F_{X1X2} = \left(\frac{1-(-5.5149E+37)}{-5.5149E+372}\right) x \left(\frac{\left(\frac{31-3+1}{2}\right)}{\left(\frac{|1-3|+1}{2}\right)}\right) = -9.6667E+00$$

After calculating the F value of factor 1 (F_{X1}), the F value of factor 2 (F_{X2}), and the interaction F value between factor 1 and factor 2 (F_{X1X2}); then a decision can be made to accept H_0 or reject H_0 through comparison of the calculated F value of each factor with the F value contained in the Wilks' Lambda table. The comparison between the calculated F value of each factor and the F value found in the Wilks' Lambda table can be seen in Table 13. The decision criteria that can be used to determine the acceptance or rejection of H_0 can be seen as follows.

If
: $F_{Count} < F_{Table}$, then accept H_0
: $F_{Count} > F_{Table}$, then reject H_0 and accept H_1

Table 13: Comparison of the F_{Count} Value of Each Factor with the F_{Table} Value in the Wilks' Lambda Table

Factor	F_{Count} Value	Mathematical Symbol	F_{Table} Wilks' Lambda's Value	Decision Criteria
F_{X1}	-4.119	<	0.417	Accept H_0
F_{X2}	7.736	>	0,650	Reject H_0 and accept H_1
F_{X1X2}	-9.667	<	0,680	Accept H_0

Based on the calculation of the F_{Count} value for each factor, the values of F_{X1}, F_{X2}, and F_{X1X2} are -7.250; 4.545; and -9.667, respectively. The F_{X1}, F_{X2}, and F_{X1X2} values from the above calculations are compared with the F_{Table} value in the Wilks' Lambda table to determine the decision criteria for accepting H_0 or rejecting H_0. It is known that the value of F_{X1} is smaller than the F_{Table} value in the Wilks' Lambda table (-7.250 < 0.417) so the decision criteria is to

ISSN No:-2456-2165 https://doi.org/10.5281/zenodo.14890837

accept H_0. This indicates that technical cultivation factors have an important effect on milkfish productivity, whiteleg shrimp productivity, and polyculture pond profits. It is also known that the value of F_{X2} is greater than the F_{Table} value in the Wilks' Lambda table (4.545 > 0.650) so the decision criteria is to reject H_0 and accept H_1. This indicates that human resource factors have an insignificant effect on milkfish productivity, whiteleg shrimp productivity, and polyculture pond profits. Meanwhile, it is known that the value of F_{X1X2} is smaller than the F_{Table} value in the Wilks' Lambda table (-9.667 < 0.680) so the decision criterion is to accept H_0. This indicates that the interaction between technical cultivation factors and human resource factors has an important effect on milkfish productivity, whiteleg shrimp productivity, and polyculture pond profits.

IV. CONCLUSION

This research contributes to the pond cultivation process conducted by polyculture pond farmers that through a two-way MANOVA model, technical cultivation factors and human resource factors simultaneously have significant effects on milkfish productivity, whiteleg shrimp productivity, and polyculture pond profits. Partially, technical cultivation factors also have a significant effect on milkfish productivity, whiteleg shrimp productivity, and profitability of polyculture ponds. Meanwhile, human resource factors have an insignificant effect on milkfish productivity, whiteleg shrimp productivity and polyculture farm profits. This can be seen based on Wilks' Lambda test on MANOVA test statistics that have been done with a confidence level of 10%.

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