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EXAMINING THE IMPACT OF INNOVATIVE SEAFOOD WASTE RECYCLING: INTEGRATING AQUA-AGROSUSTAINOPRENEURSHIP FOR COSTAL SUSTAINABLE PRACTICE

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Abstract
The global seafood industry generates a significant amount of waste, which contributes to inefficiencies in resource utilization and environmental damage. In response, innovative concepts for recycling seafood waste have emerged, particularly at the intersection of aquaculture, sustainability, and entrepreneurship, a concept which is referred to as aquaagrosustainopreneurship. The objective of this research is to study the ways in which incorporating aquaagrisustainopreneurship into the recycling of seafood waste could potentially have synergy with agricultural practices. Aqua-agrosustainopreneurs are capable of transforming waste from seafood production into valuable inputs like as organic fertilizers and bioresources through the application of sustainable entrepreneurship in aquaculture. This results in an increase in agricultural production. This study analyzes the ways in which these novel recycling processes contribute to the practices of circular economies, the preservation of the environment, and the development of new business models, all of which contribute to increasing the rate of sustainable economic growth. According to the findings, there is a pressing requirement for increased policy assistance and industry collaboration in order to scale up these innovative concepts and fulfill their full potential in terms of improving agricultural sustainability and aquaculture activities.

Keywords: Circular economy practices, Technological integration, Implementation of sustainable monitoring system, Proper education and training

Introduction

The term “Aqua-agrosustainopreneurship” refers to the combines aquaculture and agriculture with sustainable entrepreneurship. It refers to the practice of using innovative, eco-friendly methods to recycle waste from aquaculture (seafood production) into valuable resources like organic fertilizers, which can enhance agricultural productivity. This approach promotes the sustainable use of resources, reduces waste, and creates opportunities for new business models that benefit both aquaculture and agriculture.

When it comes to industries that are dependent on the extraction and consumption of natural resources, the mandate for environmentally responsible resource management is more important than it has ever been. A huge amount of waste streams are produced by the seafood industry, which is a fundamental component of the world's food systems. If these waste streams are not properly managed, they can result in negative effects on the environment, the loss of biodiversity, and major resource waste. In recent years, there has been a growing emphasis placed on shifting away from conventional garbage disposal methods and toward novel recycling ideas that are in line with the ideals of a circular economy (Caldeira, 2020). Marine trash recycling programs have the ability to effectively close resource loops, lessen ecological repercussions, and turn organic leftovers into valuable items such as fertilizers, animal feed, and biofuels. This is accomplished by rethinking garbage as a potential resource. A circular economy in the seafood industry solves waste concerns while also boosting economic resilience through the transformation of materials that were previously discarded into goods that are valuable (Gregg, 2020). This shift in perspective highlights the need of employing environmentally responsible business practices and the significant part that recycling waste can play in extending the lifespan of the company and improving the environment.

In order for this shift to take place, it is vital to incorporate cutting-edge technology that streamlines and improves the process of recycling seafood. The extraction of useful components from marine waste is made possible by technological improvements such as biochemical processing, microbial fermentation, and anaerobic digestion. As a result, the value of organic byproducts is increased across a variety of businesses. Increasing the scalability and effectiveness of seafood waste recycling systems has been made possible by digital monitoring technologies and automation (Chen, 2022). This has resulted in the maintenance of a consistent quality and the reduction of negative effects on the environment. As a result of the capabilities of digital monitoring systems to monitor the lifespan of recovered goods, oversee resource flows, and manage waste outputs, operational transparency and accountability can be ensured. Utilizing technology in an efficient manner improves the procedures for recycling seafood trash, so assuring compliance with industry standards and alignment with sustainability goals. In addition, these technical improvements lessen the reliance on conventional methods of resource extraction and encourage the development of a framework that is regenerative and aims to achieve both ecological and economic objectives (Debeaufort, 2021).

It is similarly important to maintain sustained monitoring in order to ensure that recycling initiatives for seafood waste are efficient, transparent, and in line with regulatory requirements. The use of data analytics can improve monitoring systems by supplying stakeholders with ongoing assessments of carbon emissions, waste minimization, and resource utilization. This, in turn, makes it easier to track progress and improve procedures (Beltran, 2021). These monitoring systems make it possible to continuously improve recycling methods by locating areas that could benefit from higher efficiency and additional waste reduction. In addition, sustainable monitoring systems have the potential to share information with stakeholders regarding the environmental impacts of these activities, which in turn helps to promote accountability (Ozogul, 2021). This not only improves the credibility of the industry but also satisfies the growing demand from customers for products that are environmentally friendly and traceable. As a result of sustainable monitoring's alignment with worldwide sustainability standards and reporting frameworks, recycling seafood waste is guaranteed to make a significant contribution to the achievement of broad environmental goals.

The purpose of this study is to investigate the ways in which Aqua-agroSustainopreneurship, which is a complete framework that integrates aquaculture, agriculture, sustainability, and entrepreneurship for the purpose of environmental stewardship and economic development, intersects with the notions of the circular economy and recycling seafood waste. This study examines technical breakthroughs that allow successful recycling and monitoring systems that track progress in order to highlight the various tactics that are required to transform seafood waste management into a practice that is sustainable (Siddik, 2020). The paper offers insights into how recycling seafood trash can generate resilient and sustainable business models by employing technology and constant monitoring. These insights are supported by case studies and current developments in the field (Jariyasakoolroj, 2020). By illustrating how recycling seafood trash can serve as a model for other industries that are moving to circular, technologically advanced, and sustainably monitored waste management solutions, the purpose of this study is to make a contribution to the ongoing conversation about sustainable business practices.

Literature Review

Due to the rapid growth of the global population and the needs of consumers over the course of the previous century, there has been a huge increase in the consumption of energy and resources, which has therefore had a severe impact on ecosystems and biodiversity. While this is happening, the environment has been deteriorating and human health has been put in jeopardy due to improper disposal of industrial waste and byproducts simultaneously. In light of this, a sustainable food resource development system that makes use of effective recycling for the purpose of minimizing waste will make a contribution to the preservation of ecology and the environment (Huang, 2021). As the value of resources continues to rise, the circular bio-economy has flourished in a number of different industries, including politics, academics, and different businesses. According to estimates provided by the Food and Agriculture Organization of the United Nations (FAO), twenty-five percent of the more than one hundred and seventy-five million tons of seafood that were produced worldwide in 2017—including fish, mollusks, crustaceans, and other aquatic organisms—were wasted. Crustaceans account for around forty percent of the meat that is consumed, whereas sixty percent of the meat that is consumed is inedible, resulting in a significant amount of waste of these organisms. The entire amount of trash generated from the production of lobster, crab, and prawns was between 7 and 9 million tons in the year 2020, when the global output of crustaceans reached 16.83 million tons. In order to effectively allocate this seafood waste and prevent any damage to the ecosystem, it is vital to implement management systems that are effective. Food scraps from seafood are a significant source of nutrition for the human diet and are abundant in a wide variety of various components.

The packaging of food helps to maintain its freshness and prolong its shelf life. Consequently, this results in a reduction in the amount of food that is lost due to deterioration that occurs during transportation or storage. In most cases, the end-of-life scenario for plastics that are sourced from fossil fuels leads to negative consequences on the environment. These implications include increased emissions of greenhouse gases and the production of microplastics (Mousavi, 2021). Eliminating plastic from food packaging and replacing it with materials that are both biodegradable and renewable will drastically reduce the amount of waste produced by plastic around the world. Recent research have shown that fish gelatin and chitosan, which are both recovered from seafood waste, has antioxidant and antibacterial properties. These substances have the potential to serve as effective alternatives to plastic goods for food packaging. This would result in a reduction in the amount of food that goes bad, an improvement in post-processing operations, and an extension of the shelf life of the food. At the same time that it is vital to control the sustainable exploitation of seafood waste and byproducts, it is also essential to ensure the sustainability of resources and to prevent environmental problems. In recent years, there has been a significant amount of study conducted on the usage of components and compounds obtained from industrial marine wastes across a variety of industries (Salem, 2021). These industries include agriculture, aquaculture feed, functional foods, and medications. The byproducts and waste materials that are produced during the processing of fish, such as skins, heads, intestines, bones, scales, and fins, can be used to produce substances that have the potential to be of major importance. Gelatin from fish can be isolated from fish skin and then processed further into films and coatings that can be used in the culinary industry. Pepsin, pancreatin, pancreatic rennet, collagenase, and lipase are several of the enzymes that are found in abundance in fish intestines. The hydrolysis of minced fish flesh can result in the production of bioactive peptides. Due to the high calcium content of fish bones, them can be pulverized into fish bone powder for the purpose of providing calcium supplements. This powder can also serve as an innovative component in the food processing industry. The brain of a fish is improved by lecithin and polyunsaturated fatty acids, which may also help with memory concerns, sleep disorders, and cardiovascular conditions. In order to provide products that contribute to the development of the healthcare industry, it is possible to extract fish oil from the head of the fish.

It is anticipated that the global population will reach 9.6 billion by the year 2025, which would result in an increase in the demand for food that is greater than fifty percent. Plastic materials, which are mostly derived from petrochemicals, have become the predominant material for food packaging across a variety of categories, including meat, dairy products, fruits, vegetables, and both fresh and frozen foods. In recent years, plastic materials have become indispensable in a variety of fields. There has been a lot of recent research done on the concept of using fish gelatin to make edible films for the purpose of packaging food. A pectin– fish gelatin edible film was developed by Bermudez et al. in order to prevent lipid oxidation in beef during a seven-day storage period at a temperature of four degrees Celsius. This allowed raw beef to be preserved under refrigerated conditions. Using gelatin that was taken from the skin of the dogfish (Squalus acanthias), Salem and colleagues were able to construct a functional gelatin-based film that is ideal for active packaging in order to preserve the quality of cheese. Jeya

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Shakila and colleagues created four distinct types of films using gelatin derived from the bones of red snapper and grouper. These films included gelatin, gelatin including montmorillonite, gelatin containing chitosan, and gelatin containing montmorillonite containing chitosan. Subsequently, mechanical and barrier properties of these films were compared to those of gelatin films derived from mammalian gelatin.

Objectives

1. To examine the extent to which seafood waste is utilized as a value-added resource in promoting sustainable business practices within the framework of Aqua- agrosustainopreneurship.
2. To assess the role of environmental awareness and employee sensitization in enhancing seafood waste recycling practices.
3. To evaluate the impact of skill development and innovation in enhancing seafood waste recycling efficiency.
4. To analyze the adoption and effectiveness of standardized guidelines and networks in sustainable seafood waste management.
5. To investigate the economic impact of seafood waste recycling on seafood-based entrepreneurial ventures.

Methodology

This research makes use of a mixed-method approach, which incorporates both qualitative and quantitative data, in order to provide a full examination of the recycling of seafood waste, applications of circular economy, and the role of Aqua-AgroSustainopreneurship in encouraging sustainable practices within the industry. This mixed-model approach aims to collect a variety of insights that place an emphasis on statistical trends while also capturing comprehensive perspectives from key stakeholders in the seafood industry. These stakeholders include individuals who are involved in the implementation of technology, waste management, and sustainable entrepreneurship. For the purpose of this project, primary data will be collected through the use of structured interviews and questionnaires addressed toward individuals and organizations that are active in sustainable business practices and recycling of seafood trash. A variety of professionals in the field of waste management, aquaculture producers, and business owners will be among the participants. Secondary data will consist of industry papers, scholarly publications, and case studies that provide an explanation of modern research methodology and findings concerning the recycling of seafood waste, frameworks for circular economies, and sustainable entrepreneurship in aquaculture and agriculture. Published reports from environmental agencies, governmental and non-governmental organizations, and industry groups will be examined in order to provide contextual information and to validate the findings obtained from primary data.

Analysis Demographic profile

Age	**Frequency**	**Percent**	**Mean**	**SD**
Below 25 years	21	9.50	3.47	1.569
26-35 years	45	20.50		
36-45 years	59	26.80		
46-55 years	37	16.80		
56-65 years	20	9.10		
Above 65 years	38	17.30		

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Gender	Frequency	Percent	Mean	SD
Male	125	56.81	1.43	0.496
Female	95	43.20		

City	Frequency	Percent	Mean	SD
Metro	117	53.20	1.47	0.5
Non Metro	103	46.80		

Annual Income	Frequency	Percent	Mean	SD
Below 4 Lakhs	16	7.30	2.88	1.018
4-7 Lakhs	64	29.10		
8-11 Lakhs	86	39.10		
12-15 Lakhs	38	17.30		
Above 15 Lakhs	16	7.30		

Experience	Frequency	Percent	Mean	SD
0-2 Years	8	3.60	3.83	1.144
2-5 Years	21	9.50		
5-10 Years	54	24.50		
10-15 Years	54	24.50		
More than 15 Years	83	37.70		
Total	**220**	**100.00**		

The demographic profile of the individuals who participated in the research projects on creative seafood waste recycling and Aqua-AgroSustainopreneurship is of utmost importance since it

offers a crucial insight of the background and range of the participant pool. An review of the age distribution reveals that there is strong representation across all age categories, with the largest proportion of respondents falling within the age range of 36–45 years (26.8%), followed by those who are between the ages of 46 and 55 (16.8%), and then those who are over the age of 65 (17.3%). It was the youngest responders that had the lowest representation, with around 9.5% of them being under the age of 25. On a scale where higher categories imply rising age groups, the average age category of the respondents was around 3.47 years old. This indicates that the distribution of the respondents was rather uniform, encompassing the middle to late stages of adulthood. The standard deviation was 1.569. The inclusion of people of varying ages is advantageous since it allows for the presentation of perspectives

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from both novices and seasoned professionals in the seafood sector. With males accounting for 56.8% of the sample and women accounting for 43.2%, the gender distribution among the respondents shows a level of engagement that is somewhere in the middle. The computed mean of 1.43 and the standard deviation of 0.496 point to a somewhat higher frequency of male respondents, possibly reflecting the gendered dynamics in commercial and operational roles in the seafood and recycling sectors. This is based on the assumption that binary coding is used, with 1 representing male and 2 representing female.

Despite the fact that respondents were almost equally distributed across metropolitan and nonmetropolitan cities, only 53.2% of them resided in metropolitan regions. This indicates that metropolitan areas represented a very tiny majority. The sample was nearly evenly divided between urban and semi-urban/rural respondents, with a mean score of 1.47 and a standard deviation of 0.5. As a result, the sample provides a comprehensive picture of the strategies that are used to recycle seafood waste at various degrees of urbanisation. With regard to the evaluation of regional practices, the accessibility of infrastructure, and the understanding of environmentally responsible recycling technologies, this variability may be of critical importance. Based on the distribution of yearly income, it is seen that a sizeable 39.1% of respondents earn between ₹8 and ₹11 lakhs annually, while 29.1% of respondents earn between ₹4 and ₹7 lakhs. The groups that fall at both the lower and upper ends of the income range, namely those with incomes below ₹4 lakhs and those with incomes exceeding ₹15 lakhs, make up just 7.3% of the sample. With a mean of 2.88 and a standard deviation of 1.018, the average income group indicates that there is a concentration of middle-income earners. As a result, their investment capacity, adoption of innovation, and dedication to sustainability in seafood recycling initiatives are all influenced by this concentration.

The majority of the responses were from professionals with a significant amount of experience, with 37.7% of them having more than 15 years of experience. Additionally, 49% of the respondents had between 5 and 15 years of years of experience. Only 13.1% of those who participated in the survey said that they had fewer than five years of experience. With a standard deviation of 1.144, the average experience score of 3.83 highlights the advanced professional profile of the sample, so indicating that most of the insights gained in this study come from the points of view of seasoned people most likely occupying strategic or decision-making roles within their respective seafood or sustainability companies

Table 2: Correlation analysis

Correlations	**Value added Resources**	**Environmental Benefits**	**Skill Development**	**Innovative Approaches**	**Sustainable Practices**
Value added Resources	1	.764**	.755**	.874**	.826**
Environmental Benefits	.764**	1	.796**	.826**	.908**
Skill Development	.755**	.796**	1	.800**	.801**
Innovative Approaches	.874**	.826**	.800**	1	.878**
Sustainable Practices	.826**	.908**	.801**	.878**	1

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The correlation analysis that was carried out in the research project on creative seafood waste recycling reveals a strong and statistically significant association between all of the variables that were analysed, including value-added resources, environmental advantages, skill development, innovative techniques, and sustainable practices. In order to further understand this, Aqua- agroSustainopreneurship is helpful. There is a substantial positive association between environmental benefits and sustainable practices (r = 0.908), which indicates that organisations' commitment to sustainable business practices simultaneously grows as they realize and support the environmental advantages of recovering seafood trash. Given the strong relationship between the two, it seems that efforts aimed at achieving long-term sustainability are fundamentally connected to environmental awareness. The correlation between innovative approaches and sustainable practices is fairly good (r = 0.878), which indicates that fostering innovation in the recycling processes for seafood waste provides a positive boost to the sustainable operations of a firm. In most cases, innovation is the driving force behind businesses transitioning from conventional trash disposal practices to more circular, value generating ways. In addition, there is a significant positive connection between Value Added Resources and Innovative Approaches (r = 0.874), which highlights the concept that the creative reuse of marine waste into new goods or applications places creativity as both a method and an effect of this endeavour towards innovation.

The most significant correlations were discovered between Environmental Benefits (r = 0.796) and Sustainable Practices (r = 0.801), indicating that skill development has a substantial relationship with all of the other categories. As a result, this demonstrates how training in advanced recycling procedures and capacity development may assist businesses in enhancing their operational efficiency while simultaneously increasing their environmental requirements and overall sustainability. There is a good link between Value Added Resources and Sustainable Practices (r = 0.826), which indicates that businesses that place a high premium on transforming waste into valuable products are more likely to be in agreement with the desired outcomes of sustainable development objectives.

Table 3: Regression analysis

Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**p value**
Regression	337.843	4	84.461	402.129	.000b
Residual	45.157	215	0.21		
Total	383	219			
Coefficients	B	Std. Error	Beta	t	p value
Innovative Approaches	0.295	0.062	0.275	4.787	0.00
a Dependent Variable: Sustainable Practices					
(Constant)	-0.163	0.102		-1.594	0.11
Value added Resources	0.142	0.05	0.14	2.845	0.01
Environmental Benefits	0.561	0.048	0.534	11.746	0.00
Skill Development	0.056	0.048	0.05	1.168	0.24

This is shown by the statistically significant and robust model of the regression analysis that was carried out in order to analyse the influence of several factors on sustainable practices pertaining to the recycling of seafood waste and Aqua-agroSustainopreneurship. Considering that the F-value for the regression model is 402.129 and the p-value is 0.000, which is far lower than the standard significance requirement of 0.05, the model summary demonstrates that the regression model is extremely significant. The conclusion that can be drawn from this is that the independent variables Value Added Resources, Environmental Benefits, Skill Development, and Innovative Approaches have a significant impact on the dependent variable, Sustainable Practices. The model explains a substantial percentage of the variation in sustainable behaviours and provides a small residual error (45.157). This is because the regression sum of squares (337.843) reflects the majority of the overall variance (383), which results in the model producing a small residual error. It is clear from this that the model is quite effective at describing things. The study of the coefficients reveals that Environmental Benefits is the most significant predictor of sustainable behaviours. This is shown by the fact that the standardised beta coefficient is 0.534, the t-value is 11.746, and the p-value is 0.000, which is extremely significant. It would seem from this that businesses are progressively becoming more aware of the benefits of recycling seafood trash, which leads to a large rise in the usage of sustainable practices by these businesses. Innovative Approaches is a significant contribution, as seen by its beta coefficient of 0.275 and t-value of 4.787. This is due to the fact that advancements in recycling processes and procedures have a positive impact on sustainability initiatives. Value Added Resources (beta = 0.14, p = 0.01) provide a marginal but statistically significant advantage to sustainable practices. This indicates that the conversion of seafood waste into useful things or materials is a key step towards achieving the overall objective of sustainability.

According to this model, the development of skills seems to have a minimal direct influence on sustainable practices. This conclusion is based on the fact that the beta coefficient is just slightly less than 0.05, and the p-value is 0.24, which is just over the threshold of statistical significance. The implication of this is that the development of skills may not directly impact the adoption of sustainable practices, even if it may contribute to the creation of an environment that is conducive to recycling, unless it is backed by other motivating reasons or an integrated part of an all-encompassing organisational strategy.

Table 4: ANOVA 1

Value added Resources	**Sum of Squares**	**df**	**Mean Square**	**F**	**p value**
Between Groups	287.729	4	71.932	182.34	0.00
Within Groups	84.817	215	0.394		
Total	372.545	219			

The findings of the analysis of variance (ANOVA) for the variable "Value Added Resources" give important fresh insights on the variations in attitudes or replies across the numerous respondent groups in the research that addressed the recycling of seafood trash and the potential value enhancement of this practice. The table demonstrates that the entire variance in the data may be divided between the variation between groups (287.729) and the variation within groups (84.817), which results in a total sum of squares value of 372.545. The perspectives of various groups with respect to the use of seafood waste as a resource with value-added clearly demonstrate considerable disparities between the total of squares

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across groups and the sum of squares within groups. Considering that the mean square for the between-groups category was determined to be 71.932, the mean square for the within-groups category was 0.394, which contrasts with this and results in an F-value of 182.34. The F-value is very high, and the pvalue that corresponds to it is 0.00, which is far lower than the standard statistical significance criteria of 0.05. This demonstrates beyond a reasonable doubt that the differences that have been observed between the groups are statistically significant and very unlikely to be the product of random chance. The findings indicate that respondents who were categorised according to age, income, experience, or business orientation exhibited considerable variances in their perspectives or approaches to the implementation of seafood waste for the purpose of value addition.

The whole conceptual framework of AquaGriSustainability is strengthened as a consequence of this outcome, which demonstrates that different stakeholder groups have different expectations for the utilisation of value-added resources. On the contrary, it is created by a variety of surroundings, objectives, and abilities. It is possible that the considerable discrepancies across the categories may be explained by varying degrees of knowledge, access to innovation, waste recycling infrastructure, or company strategies that place a focus on sustainable development. When it comes to boosting seafood waste recycling as a value-added activity and a driver of sustainable behaviours, the findings of the ANOVA demonstrate the need of knowing group-specific attitudes and operational tactics. In light of this, it is clear that improved value recovery from seafood waste throughout the industry requires the implementation of individualised policies and initiatives that take into account the specific requirements and constraints of certain demographic or operational groups.

Table 5: ANOVA 2

Environmental Benefits	Sum of Squares	df	Mean Square	F	p value
Between Groups	294.058	4	73.515	297.932	0.00
Within Groups	53.051	215	0.247		
Total	347.109	219			

The findings of the second analysis of variance (ANOVA) for the variable "Environmental Benefits" demonstrate that there are significant variations between the groups in terms of their perspectives or experiences in relation to the environmental benefits of recycling seafood trash. The overall variance in the replies is quantified by a total sum of squares of 347.109; this variable is then partitioned into a between-groups sum of squares of 294.058 and a withingroups sum of 53.051. It is possible that group-level factors such as age, business background, city of operation, or experience in the seafood industry may have a significant influence on their awareness or interpretation of environmental benefits. This is suggested by the significant degree of variation that exists between groups in comparison to the variation that exists within groups. The mean square for the variation that occurs within groups is much lower, coming in at 0.247, whilst the mean square for the variance that occurs across groups is 73.515. Consequently, this results in a rather high F-value of 297.932, which demonstrates the extent to which the differences between the groups are significant. In addition, the p-value associated with this F-test is 0.00, which indicates that the observed changes are statistically significant at the greatest degree of confidence and are not the consequence of fluctuations caused by random sampling. The many and substantial perspectives or applications of environmentally friendly behaviours across a variety of respondent groups are unequivocally validated by this outcome.

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More specifically, this conclusion pertains to the incorporation of recycling of seafood waste into ecologically friendly business models, such as those that are supported by Aqua-groSustainopreneurship. It demonstrates that the prioritisation and use of environmental advantages are influenced by a variety of operational or demographic conditions; hence, stakeholders may not necessarily see them as an environmental benefit. It is possible that these discrepancies are the consequence of variances in access to recycling technology, educational performance, and exposure to legislation, local environmental consciousness, or commitment to sustainability goals. The results of the ANOVA shed light on the important need for contexts pecific knowledge, appropriate policy interventions, and capacity-building programmes in order to ensure that all stakeholders understand and actively participate in the process of maximising the environmental advantages of recycling seafood trash.

Table 6: ANOVA 3

Skill Development	Sum of Squares	df	Mean Square	F	p value
Between Groups	221.804	4	55.451	140.302	0.00
Within Groups	84.974	215	0.395		
Total	306.777	219			

The findings of the analysis of variance (ANOVA) on the variable "Skill Development" demonstrate that there are statistically significant differences between the opinions or participation of various respondent groups in their perspectives or engagement with skill development activities connected to the recycling of seafood trash. There is a total sum of squares of 306.777, which quantifies the whole variance in the data. This variance is divided into 221.804 for the variation between groups and 84.974 for the variance within groups separately. The significant variations in the variance between groups and the variance within groups demonstrate that the views or experiences of respondents about skill development programmes in this area vary substantially depending on specific categorical criteria such as age, income, years of experience, or the sort of firm they work for. The value of the mean square for the category that differs across groups is 55.451, whereas the value for the category that is within groups is 0.395. There are substantial group-level variances, as shown by the relatively high F-value of 140.302, which was derived from the significant difference between the two mean squares of the two groups. The fact that the p-value is 0.00 indicates that the differences in skill improvement that exist between the different responder groups are statistically significant under a degree of confidence that is more than 0.05. The variances in group perspectives or advantages about the opportunities for skill development in seafood waste recycling may be explained by real, underlying contextual or exposure variables rather than by sheer chance.

In the context of the overarching framework of AquaGriSustainopreneurship, which seeks to actively encourage innovation and sustainability via the methods of knowledge upgrading, this outcome is very significant. The results indicate that there is a disparity in the distribution of access to and efficacy of chances for skill development. This disparity may be the result of inequalities in institutional support, access to training programmes, educational background, or business readiness. It is imperative that these disparities be rectified if we are to successfully adopt sustainable seafood waste management. It is essential to have individualised skill development programmes that cater to the specific requirements and capabilities of various stakeholder groups in order to equip the workforce with the ability to embrace new recycling procedures. The findings of the ANOVA indicate that there is a need for more institutional measures to enhance inclusiveness, equity, and the alignment of skill development in this sector with the ever-changing requirements of the environment and the entrepreneurial sector.

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Table 7: ANOVA 4

Innovative Approaches	Sum of Squares	df	Mean Square	F	p value
Between Groups	273.12	4	68.28	246.829	0.00
Within Groups	59.475	215	0.277		
Total	332.595	219			

The fourth analysis of variance (ANOVA) research on the variable "Innovative Approaches" reveals that there is a pretty substantial difference between the various responder groups in terms of their acceptance or perception of creative ideas in the processing of seafood waste recycling. The broad variation in replies is represented by a total sum of squares of 332.595; this sum of squares is broken down into a between-groups sum of squares of 273.12 and a within-groups sum of squares of 59.475. The relatively high value of the between-groups component indicates that there are significant variances in the perspectives or applications of creative ideas that are shared by a number of different groups. This might be an indication of disparities in organisational capacity, experience in current technology, management's commitment towards innovation, or contextual variables such as information relevant to a particular industry, geographic location, or technical competency. It was determined that the mean square value for the between-groups variance was 68.28, which is much higher than the mean square value of 0.277 that was found within the groups. The F-value for the evidence of variance among groups is 246.829, which indicates that the evidence is quite strong. Furthermore, the p-value is 0.00, which demonstrates that the statistical significance of these data is confirmed at a level that is far lower than the traditional threshold of 0.05. This leads one to believe that the variances in the acceptance or acknowledgement of creative ideas are not random in origin, but rather that they are defined by true distinctions that exist between different communities.

In the context of the Aqua-agroSustainopreneurship model, which places an emphasis on environmental stewardship and entrepreneurial inventiveness as its top priorities, these results are very important for the management of surplus seafood in a sustainable manner. There is a clear distinction between the two, which shows that certain businesses may be at the forefront of introducing innovative recycling technology or business models, while others may continue to function within older or less flexible systems. There might be a number of factors that contribute to this gap, including variations in the availability of resources, infrastructure, political support, or appreciation of the creative potential available to the business. Therefore, in order to build an environment that is more generally sustainable, it is necessary to make concerted efforts to facilitate the sharing of information, the provision of technical assistance, and the promotion of innovation via the implementation of policies pertaining to training, networking, and financial resources across all stakeholder groups. The results of the ANOVA highlight the relevance of promoting and supporting inclusive innovation in order to ensure that every participant in the seafood recycling value chain has the opportunity to participate in and profit from innovative, efficient, and environmentally friendly means of collecting and recycling seafood.

Discussion

This study provides a full knowledge of the application and perspective of innovative seafood waste recycling strategies within the developing Aqua-agroSustainopreneurship framework. This awareness is provided via the analysis and interpretation of the data that was collected. This idea is founded on aquaculture, sustainable agriculture, and entrepreneurial innovation, and it integrates these three

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approaches in order to convert waste seafood into valuable resources, so contributing to the preservation of the environment and the resilience of the economy. The statistical investigations, which include demographic profiles, correlation, regression, and ANOVA tests, suggest that great progress is being made in developing sustainable practices. This is despite the fact that there are variances across various groups in terms of general acceptability, awareness, and skill development (Gumienna, 2021).

It has been shown via demographic research that individuals belonging to a wide range of age groups, economic levels, and urban categories are involved in activities that are associated with seafood waste. This suggests that there is a broad and inclusive foundation for the potential implementation of sustainable measures. A thorough research found that factors such as age, level of expertise, and geographic region all have a role in determining the extent to which individuals participate in recycling activities and their perspectives on these activities. The examination of correlation highlights the degree to which significant factors, such as the utilisation of resources with added value, the benefits to the environment, the development of skills, creative methods, and sustainable practices, are highly interconnected (Costa, 2021). The presence of higher correlation values indicates that a large number of factors are connected, which means that advancements in one dimension will most likely assist in the advancement of other dimensions as well. This lends credence to the viewpoint that a comprehensive and unified strategy is necessary in order to achieve the goal of increasing the recycling of sustainable seafood waste.

The regression analysis sheds light on the elements that have the greatest impact on the acceptability of environmentally responsible behaviours. It would seem that the most significant predictors are the creative ways and the environmental advantages that are associated with the situation (Hamdi, 2020). According to the findings of this research, businesses have a significantly increased likelihood of adopting environmentally responsible practices when they understand the significance of various environmental benefits and include innovative ideas into their operations. On the other hand, although skill development is significant, it has a smaller statistical impact in the regression model. This suggests that even though training and capacity building are essential, they need to be supplemented by specific incentives and structural changes in order for us to change behaviour in an appropriate manner.
In order to provide evidence for these findings, the results of the ANOVA reveal substantial differences between the respondent groups with regard to each and every one of the essential components. For example, there are distinct discrepancies in the viewpoints about value-added resources, environmental advantages, talent development, and creative techniques. These differences highlight to the reality that not all stakeholders are equally prepared or qualified to engage in advanced seafood waste recycling (Kayani, 2021). These disparities may be the consequence of variances in the availability of training, money, infrastructure, or regulatory assistance at the local level. Given the statistical significance of these disparities, it is imperative that localised support networks and targeted legislative acts be implemented as soon as possible in order to successfully address these disparities.

Conclusion

The findings of this research shed light on the complex and interconnected aspects of the various techniques of recycling sustainable seafood trash. A feasible strategy for achieving environmental and financial objectives is presented by Aqua-agroSustainopreneurship. This model is dependent on the comprehensive integration of innovation, awareness, skill development, and ecosystem support. When it comes to the implementation of sustainable practices, businesses that acknowledge and make use of the financial and environmental worth of seafood waste are more likely to provide good results. Nevertheless, unequal access to resources and opportunities undermines the possibility of equitable growth. A concerted effort on the part of lawmakers, corporations, educational institutions, and environmental organizations is required in order to achieve comprehensive, creative, and effective recycling of seafood waste in a way that is sustainable and environmentally responsible. The use of resources should be maximized, entrepreneurial innovation should be supported, and long-term sustainability should be improved, according to this paper, which urge for purposeful steps to be taken within the fish industry and other industries.

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