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Perception towards Multi-loop Aquaponic System in Mauritius: Structural Equation Modelling

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Abstract:
Multi-loop Aquaponic System is a detached ecosystem for both plants and fish, with increased nutrients as well as increased output efficiency. In the Multi-loop Aquaponic system, the plant growth and nutrient uptake, fish survival are dependent on climate, weather conditions, humidity (RH), carbon dioxide (CO2) levels. The study attempts to test the Multi-loop Aquaponic system empirically for the Mauritian context. Knowledge of Aquaponics, acceptance, and willingness to pay for Aquaponics tested. A drop-off survey is conducted using a well-structured questionnaire (5-point Likert scale). The respondent's level is 79% (397 responses out of 500 questionnaires circulated) good fit for the analysis. Factor Analysis (FA), Confirmatory Factor Analysis (CFA), followed by Structural Equation Modelling (SEM) used for the study. The findings show Mauritians are having up-to-date knowledge and information about Aquaponics and willing to espouse the system.

Keywords: Multi-loop Aquaponic system, Ecological modernization theory, SEM, Aquaponics, willingness

1. Introduction

Aquaponics is a combination of growing organic (100%) crops and fish in a sustainable, pesticide, and herbicide-free system. Mauritius, as an emerging nation trying to widen and appraise their organic cultivation practices of agro-based food products, aquaponics is one among them (Emerenciano et. al., 2017; Goddek et. al., 2018; Yogev et. al., 2016, Goddek and Keesman, 2018). Though aquaponics is a topical concept in Mauritius, it is gaining momentum with green consumer behaviour (Janka et al. 2018). The country is trying to bring in drastic changes in practices to signify the consumer attitude and behavior towards Aquaponics. Ministry of Agriculture initiated funds (2018-19, Budget) for the sensitization and training of Aquaponics. Albion Fisheries Research Centre has set up for providing technical and infrastructural facilities for the budding Aquaponics in Mauritius. The ministry is promoting Aquaponics as an alternative and sustainable farming as an alternative for the ingress of food crops. Sheltered Farming Scheme, which is a ready-to-operate basis, domestically and abroad, is one among them. The `Food and Agricultural Research and Extension Institute` (FAREI) offers necessary methodological support, The `Development Bank of Mauritius` (DBM) and `Mau Bank` will give

the loans at 3 % subsidy with a tax exemption for eight years.

Multi-loop Aquaponic system designed to separate the `Recirculated Aquaculture System` (RAS) and `Hydroponic` (HP), also, a detached ecosystem with an inherent advantage for both plants and fish with minimum resources and a maximum output of crop and fish. Therefore, the study aimed at creating an aquaponic simulation model for Mauritius based on ecological modernization theory. Ecological Modernization argues in environmentalism and economic benefits (Hajer,1995). The concept is emerged during the early 1980s and taken momentum in testing globally. The underlying assumption of this theory is the environmental readaptation of economic growth. Economy and ecology combined to source the future growth and development of humans and nature. An innovative structural sort of multi-level world-system theory is accepted, which commands fundamental creative change through research and development. The overlapping features of this theory are the conception of justifiable expansion, industrial metabolism methodology, and the concept of industrial ecology. The study made scenario simulation studies on Island by means of RAS size though feigning on the fitting HP area. The results indicate the importance of healthy food consumption knowledge and understanding by the respondents and the acceptance of aquaponics products. The study adopted essential tools empirically tested in discovering mislaid components and mainly influencing determinants for accepting for the modeling and analysis of system dynamics. The paper organized to address the issues of modeling the aquaponic system at Mauritius.ight/understanding, analysis, estimation, and management.

In terms of scientific publications in sustainable agricultural practice started during 2008. According to the database, there is tremendous growth in writing in recent years, mainly in terms of innovative aquaponic methods (Pollard et at., 2017). The current exploration, 367 indexed papers in SCOPUS databank (2019) were found, in the form of chapters, research papers, working journals, conference proceedings, etc. To mention a few social sciences, energy, management, microbiology, technology, agriculture, aquaculture, and so on. Growing urban density forces the process and organization of conservative methods for water resources usage, energy, and surplus treatment practices. Aquaponics is playing a significant role in contributing to the town steering structures in terms of aquatic, energy, and food (Schuetze et. at., 2008; Binz et. at., 2010).

2 Materials and Methods

The analysis grounded by a combined study of both broad literature examination in the form of evaluation and practical phases. The leading exploratory stage is a comprehensive literature survey on the theories and models adopted for the study. Primary sources of information include academic journals, reports, scientific reviews, working papers, published books (Environmental and Agricultural sciences), consumer behavior, also infrastructure.

A questionnaire with a 5-point Likert scale developed. The questionnaire divided into 7 subsections, focussing on the demographic profile of the respondents, knowledge of organic products, Aquaponics, and its acceptance, self-image determinants, health-conscious, personality and motivational factors, and Neo Ecological Paradigm (Eleanor J Gibson, 1960) (NEP). A drop-off survey with random sampling administered, followed by expert interviews. The data converted with the help of the data binning process using SPSS software to make it more accurate for analysis. Analysis of data done with the help of IBM SPSS AMOS software, where

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Factor Analysis (FA), Confirmatory Factor Analysis (CFA), Structural Equation Modelling (SEM), followed by Path diagram drawn. The findings of this study, has identified some bottlenecks, though contributing extensively for the existing literature. Also, understanding the concrete rules of the performers tangled, the apparent status of Aquaponics, health benefits, ecological controlling matters (law in action), and willingness to pay. Further developments are identified forfish and vegetable research, production, consumer behavior, willingness to adaptand willingness to pay.

3 Results and Discussions

3a Results

Contradicting classifications are found while defining factors for NEP and Multi-loop Aquaponic Modelling theory. To be effective and efficient possible, we tried to explore testing empirically. Considering the null hypothesis 'True,' i.e., "Consumer Willingness to pay for the Aquaponics and fish co-production in Mauritius," X^2 test is computed on the sampling distribution of the test statistic (goodness of fit). Results indicates, p-value 0.013 is less than 0.05 ($p<0.05$), there is a significant impact of consumers' willingness to pay for the Aquaponics vegetables and fish co-production in Mauritius. It concluded that the NEP is active, and the Mauritian `Consumers` are willing to pay for Aquaponic food produces. The data is tested for suitability and reliability using KMO and Bartlett's test. Factor Analysis is computed for the study by defining the strength of the association among the items and normally distributed or not. The results show that the variables are typically distributed and statically significant at 0.815 (as against 0.05) and correlated. `Cronbach's alpha` is **0.889**, which specifies surprising level of internal reliability of the sample.

Table 1: Over-all Modification Described

'otal Modification Described

Factor (s)	Original Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Over-all	% of Modification	Aggregate %	Over-all	% of Modification	Aggregate %	Aggregate	% of Modification	Aggregate %
NEP2	10.729	12.772	12.772	10.729	12.772	12.772	4.986	22.664	22.664
NEP3	5.531	6.585	19.357	5.531	6.585	19.357	3.809	17.313	39.977
NEP4	5.073	6.039	25.396	5.073	6.039	25.396	2.352	10.689	50.666
NEP7	4.366	5.198	30.594	4.366	5.198	30.594	1.950	8.864	59.530
NEP10	3.627	4.317	34.912	3.627	4.317	34.912	1.259	5.723	65.253
NEP11	3.324	3.957	38.869	3.324	3.957	38.869			
NEP 13	2.590	3.084	41.952	2.590	3.084	41.952			
OP2	2.445	2.911	44.863	2.445	2.911	44.863			
OP4	2.355	2.804	47.667	2.355	2.804	47.667			
OP5	2.247	2.675	50.342	2.247	2.675	50.342			
OP6	2.056	2.447	52.789	2.056	2.447	52.789			
OP11	1.958	2.331	55.120	1.958	2.331	55.120			
OP14	1.857	2.210	57.330	1.857	2.210	57.330			
KI2	1.666	1.983	59.313	1.666	1.983	59.313			
KI3	1.559	1.855	61.168	1.559	1.855	61.168			
KI5	1.508	1.795	62.963	1.508	1.795	62.963			
KI6	1.416	1.686	64.649	1.416	1.686	64.649			
KI7	1.385	1.649	66.298	1.385	1.649	66.298			
KI9	1.297	1.544	67.841	1.297	1.544	67.841			
KI10	1.245	1.482	69.324	1.245	1.482	69.324			
KI13	1.168	1.390	70.714	1.168	1.390	70.714			
HC3	1.092	1.301	73.372	1.092	1.301	73.372			
HC8	1.067	1.271	74.642	1.067	1.271	74.642			

Abstraction Technique: Leading Factor Examination

From table 1, Eigenvalues are the sum of the variances of the factors loading values 4.98 (the value of rotation sums of squared loading). Communalities (h2) estimates the difference in each item, with item **NEP2 communalities** is **0.672** indicates that **67.2 %** of item NEP3 statically described by factor I and V. Researcher used orthogonal rotation (varimax). This method of rotation used because the researcher is considering that factors are uncorrelated and aiming to reduce the complexity of the components by making large factor scorings larger and smaller to smaller with the selected elements.

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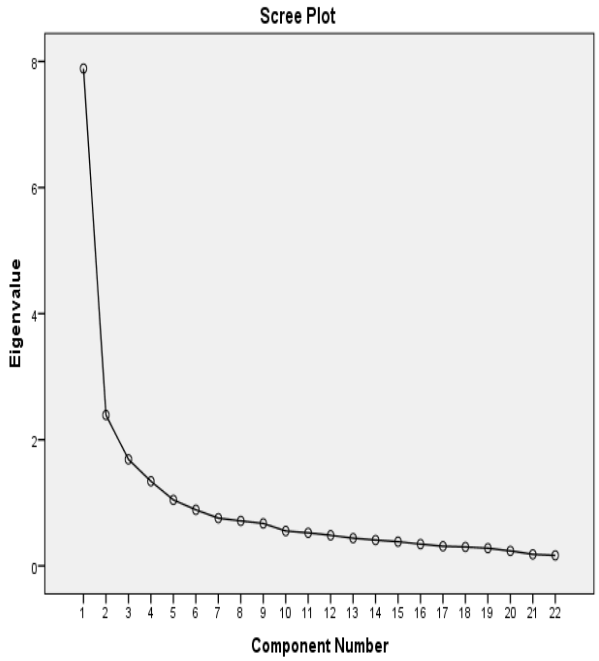
Scree plot, rotated component matrices, and Eigenvalues extracted, except one item, are not considered because this item has given negative factor loading value. Single issues discussed concluding analysis because, for any component to find, it must be more than two. The purpose of this section is to increase Organic Products related items. The results suggest that items grouped in to five aspects. `Cronbach's Alpha` for the eighty four items is 0.889, that is more than 0.7 indicate that combination derived from factor analysis is decent and satisfactory.

Figure 1: Scree Plot



(Source: Primary data collected through a questionnaire)

Table 2: Factor loading summary of individual segment – NEP (NEP2, NEP8, NEP10, NEP12, NEP15, NEP19)

Factor	Description	Factor Loading
NEP2	Humans possess fundamental right to change the nature as per their needs and wants.	0.745
NEP8	Other living beings commands equal rights along with human beings	0.679
NEP10	Humans need to protect the earth, as it is very precious planet.	0.692
NEP12	Disastrous consequences would takes place, if human try to disturb the nature.	0.668
NEP15	Human should learn how to extract the natural resources and preserve them.	0.609
NEP19	With the existing trend of misusing/ exploiting the nature, very soon we may encounter major ecological disaster.	0.845
NEP20	Sometime the present ecological situation we are facing looks like bit exaggerated.	0.891

Source: Authors Computation

3b. Discussions

The study sample was composed of 398 Aquaponic product consumers and customers in Mauritius. The correlation between the variable tested. These are vital factors that are impacting the consumers' willingness to pay and the NEP. Figure 2 shows the relationship between organic products and Aquaponics, and they significantly correlated at 0.000. Moreover, the AGFI is acceptable at .803, which is indicating the consumer's acceptance and willingness to adopt for the Aquaponics products.

Hypothesis (a): There is no substantial association among Organic Produce consumption and Aquaponics acceptance.

Figure 2: Correlation between Organic Products and Aquaponics:

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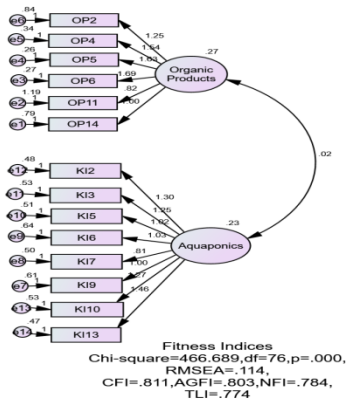

Source: Authors Computation

There is a substantial association among organic produce usage and Aquaponics acceptance by the Mauritians. The validation computed in Figure 2 and the `p` value is substantial (***). It is justified that those who are willing to consume organic products are ready to adopt for Aquaponics cultivation in Mauritius.

Exploratory Factor Analysis (EFA): Factor Analysis extracted **(**sample 398). Sample adequacy and sphericity, the KMO test used. The results are satisfactory. `P` value of Bartlett's test of sphericity is considered (0.000*).

Confirmatory Factor Analysis (CFA): CFA is a dimension to confirm the suitability of the factors.

Table 3: Consistency and Discriminant strength of Dimension-willingness to pay.

	CR	AVE	Organic Products	Aquaponics	Self-Image Determinants	NEP	Health Consciousness	Personality and Motivational Factors
Organic Products	0.881	0.601	0.775					
Aquaponics	0.910	0.592	0.603	0.770				
Self-Image Determinants	0.733	0.580	0.551	0.639	0.762			
NEP	0.878	0.474	0.655	0.515	0.751	0.689		
Health Consciousness	0.832	0.505	0.487	0.631	0.636	0.778	0.711	
Personality and Motivational Factors	0.771	0.532	0.069	0.239	0.113	0.004	0.156	0.730
Validity Concerns								

Source: Authors Computation

Structural Equation Model (SEM)

Based on the set hypothesis, SEM constructed. The affiliation among variables (Dependent/Independent), linear regression weights are considered as standard co-efficient. This standardization of regression co-efficient used for SEM.

Table4: Model Fit Indicates (First output) Modified CFA.

			Absolute fit indicators			Incremental fit indicators					
Model Fit Index	(χ2)	Df.	p-value of χ2	Df	RMSEA	CFI	GFI	AGFI	NFI	TLI	$\Delta\chi$2
Satisfactory	Smallest		<0.05	<5	<0.05(Good);<0.08 (Acceptable)	> 0.95 (Great); >0.7 (Tolerable)	Identical	Identical	>0.90 (Great); > 0.7 (Tolerable)	>0.95 (Great); >0.7 (Tolerable)	
First Output	945.1	382	0	2.47	0.073	0.881	0.81	0.77	0.817	0.865	
Modified	1332.8	207	0.00	2.17	0.117	0.621	0.832	0.701	0.584	0.578	117.9

Source: Authors Computation

Confirmatory Factor Analysis (CFA) represented in Figures 2 and 3. Corresponding values of factor presented in detail (Table 5). The chi-square (x2) is significant at 945.2, and `P`-value, 0.000 (<0.05). The perfect fit and incremental fit indicators that decides (CMIN/Df (χ2/df) the good model fit are below five and acceptable. RMSEA is less than 0.05 indicates well. It can be considered as a good model, subsequently, the values of CFI, GFI, AGFI, NFI, and TLI are above 0.9 and significant within the accepted range.

Structural Model

SEM is computed to test the Hypothesis based on the confirmation on suitability and reliability of the data. Four exogenous dormant variables considered are, Organic Products, Self-image Determinants, Aquaponics, Personality, and motivational factors and endogenous latent

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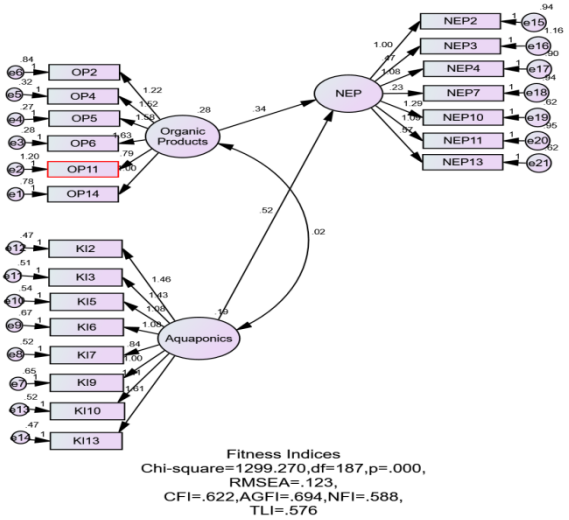
variable is NEP. The linear regression weights are used in path co-efficient (SEM Model) are measured as normal to evaluate the cause-effect relationship amongst variables (Factors).

Hypothesis (b): There is no substantial association among adoption of Aquaponics and consumption of organic products on the New Ecological Paradigm (NEP)

Figure 3(a): SEM with Modified CFA

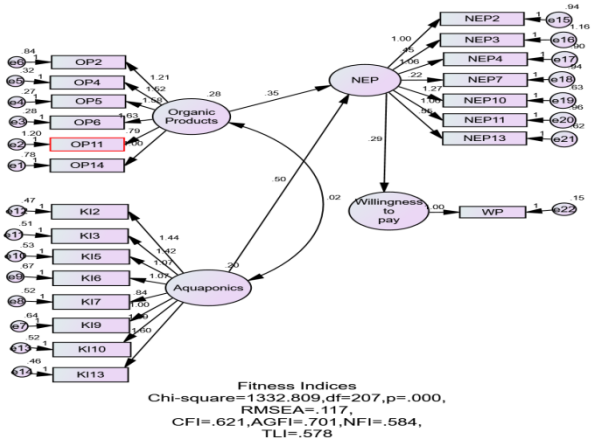


Source: Authors computation

Mauritians are very health conscious and concerned about the ecology. Figure 3(a) identifies, there is an impact of Aquaponics on NEP (p, ***).

Hypothesis ©: Mauritians are not willing to create a fund (Aquaponic Fund) to promote Aquaponics.

Figure 3(b): SEM with Modified CFA



Source: Author`s own computation

Mauritians are very knowledgeable and update in understanding the importance of aquaponics and organic products consumption, and has been very significant. (p ***).

Model Adjustment

To have better results, the modification indices are correlated to reduce the specific errors. The modified (good) results are shown in Table5: along with respective Goodness of Fit Values.

Table 5 Modified path co-efficient of structural equation model - NEP

Particulars	Estimated (path coefficient)	S.E.	t-value	p-value	Hypothesis status
Organic Products → NEP	.334	.087	3.820	***	Supported
NEP → Self-image Determinants	-.075	.081	-.930	.352	Not supported
Aquaponics → NEP	.275	.086	3.216	.001	Supported
Personality and Motivational Factors →Aquaponics	-.009	.041	-.221	.825	Not supported
Organic Products → Health Consciousness	854	.080	10.718	***	Supported
Organic Products →Aquaponics	1.044	.090	11.584	***	Supported

Source: Authors own Computation

The Organizational related factors are classified into Organic Products, NEP, Self-image Determinants, Aquaponic`s and personality, and motivational factors. The hypothesis for organic product opinions for NEP supported with p-value (***), NEP factor not supported to self-imagine determinants by p-value (0.352), Aquaponics to NEP factors reinforced with p-value (0.001), Personality then Motivational Factors to Aquaponics factors not supported with p-value (0.825). However, the overall impression of Organic Products on Aquaponics helped with the p-value (***) <0.05.

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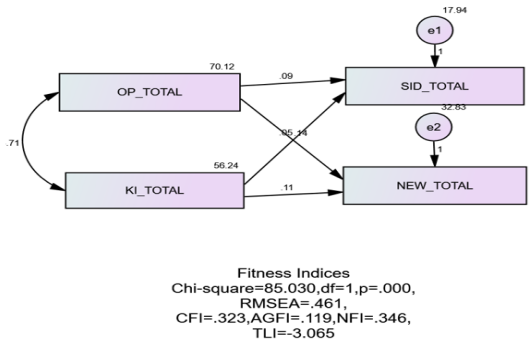
Figure 4: SEM path diagram



Source: Authors Computation
OP_TOTAL = Organic Products
KI_TOTAL = Aquaponics
SID_TOTAL = NEP
NEW_TOTAL = Willingness to pay

The factors classified as Organic Products, Aquaponics, NEP, and Willingness to pay. The hypothesis supported by p-value and significant at ***.

4 Conclusion

The original constructs of Multi-loop Aquaponic Modelling are tested with the Ecological Modernization theory to investigate the behavior and acceptance of Aquaponic products in Mauritius. `Willingness to pay for organic products` in improving health to have a healthy lifestyle assessed and tested empirically. The drive for this study is to inspire Mauritians to adopt for Aquaponic cultivation and organic product consumption. As the country is deteriorating in terms of balancing the right dietary conditions, this study may provide some insights for the community to have a better understanding of the concept. We tested the respondent's demographic profile with the model and set the hypothesis. Personal and motivational factors also examined along with the proposed explanation. The results show that Mauritians are moving towards the comprehensive manner of realizing the importance of organic product cultivation and consumption for a healthy lifestyle. Ecological products knowledge and Aquaponics is positive and influencing each other. Similarly, NEP has an impact on the above. The respondents are very positive in creating a fund for preserving, adopting, and for sustainable healthy aquaponic cultivation practices for Mauritius. The findings of this study may have a strong implication on the policymakers, consumers, traders, and the academicians who are into research and development. Though there are limitations, this study being first and foremost in the country may be a useful literature contribution in Aquaponics for the further researcher to take over.

5 Limitations and Further Research

For any research, limitations are inherent. For this study, we encountered many limitations; more important to mention here is to make the respondents understand the aim of the research and how the investigation is going to be useful for society. Data collection was very tedious since we have targeted the general public more. Data binning done since there were many missing observations in the feedback form.

The methodology and methods were very much suitable and advanced, but the sample size is very less for the country.

Further research can be undertaken with more sample size as representing the sample to have more accuracy in feedback.

Conflict of Interest: The authors have no conflict of interest.

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