Pertanika J. Soc. Sci. & Hum. 26 (4): 2867 - 2882 (2018)

PERTANIKA JOURNALS

SOCIAL SCIENCES & HUMANITIES

Journal homepage: http://www.pertanika.upm.edu.my/

Analysis of Factors for Determining Suitable Site for Giant Freshwater Prawn (*Macrobrachium rosenbergii*) Farming Through the Local Knowledge in Negeri Sembilan of Peninsular Malaysia

Ezekiel, B. B.[1,2], Firuza, B. M.[1]*, Mohammad, L. A.[3,4] and Subha, B.[3]

[1]*Department of Geography, Faculty of Arts and Social Sciences, University of Malaya, 50603 Selangor, Malaysia*

[2]*Department of Geography, Faculty of Social and Management Sciences, Taraba State University Jalingo, Taraba 660242, Nigeria*

[3]*Institute of Biological Science, Division of Genetics and Molecular Biology and Centre of Biotechnology for Agriculture, CEBAR, University of Malaya, Selangor 50603, Malaysia*

[4]*Department of Aquaculture, Patuakhali Science and Technology University, Patuakhali 8602, Bangladesh*

ABSTRACT

Prawn farming is one of the most important sectors emerging in the aquaculture industries in Malaysia which requires the consideration of the factors determining its spatial distribution. However, institutions charged with the responsibility of land suitability classification often neglect the incorporation of the local knowledge in their land use planning. The aim of the study was to identify the factors that determine the suitability of a site for giant freshwater prawn (*Macrobrachium rosenbergii*) farming in Negeri Sembilan of Peninsular Malaysia through the local knowledge. Data were collected from 64 prawn farmers and 10 fisheries officers in Negeri Sembilan using a questionnaire. Twelve factors were identified comprising water qualities (distance to sources of water, water temperature, water pH, distance to source of pollution), soil characteristics (land use type, slope, elevation, soil texture) and infrastructure facilities (distance to roads, distance to market, distance to electricity, distance to fry source). Pearson correlation and multiple regression statistics were applied to analyse the data. The correlation result revealed that giant freshwater prawn farming was greatly affected by water qualities with $r(62) = 0.669$, $p=0.000$ values, soil characteristics $r(62) = 0.559$, $p = 0.000$ values, and infrastructure factors $r(62) = 0.566$ with $p = 0.000$ values. The regression

ARTICLE INFO

Article history:
Received: 10 October 2017
Accepted: 21 May 2018
Published: 24 December 2018

E-mail addresses:
firuza@um.edu.my (Begham Mustafa Firuza)
bwadiben@gmail.com (Benjamin Bwadi Ezekiel)
lokman.fri@gmail.com (Lokman Ali Mohammad)
subhabhassu@um.edu.my (Bhassu Subha)
* Corresponding author

ISSN: 0128-7702
e-ISSN 2231-8534

analysis indicated that the coefficient of determination $R^2 = 0.951$, meaning that 95.1% of suitability is affected by the water quality, soil characteristics and the infrastructure facilities. Therefore, the determination of the factor for a suitable site for prawn farming can be achieved through the local knowledge.

Keywords: Analysis of land factors, giant freshwater prawn farming, local knowledge, Negeri Sembilan of Peninsular Malaysia, site suitability

INTRODUCTION

Organisations charged with the responsibility of land suitability classification often neglect the incorporation of the local knowledge in their land use planning. Lack of incorporating the local knowledge resulted in wrong suitability estimations in the past (Calvo-Iglesias, Crecente-Maseda, & Fra-Paleo, 2006; Chambers, Corbett, Keller, & Wood, 2004). The local knowledge is very frequently built on a collective knowledge of all aspects of land concurrently. The local indigenous understandings of a specific environment in which the people live include its physical, biological, and socio-economic aspects, and the way these interrelate. This is considered appropriate for identifying land factors and requirements for any land use. The locals' perspective of a 'good' land may include aspects that result in good crop yield or which give subsistence and/or profit.

Giant freshwater prawns (*Macrobrachium roesnbergii*) are found throughout the tropical and the sub-tropical countries of the world (New & Kutty, 2010). It is the largest commercial species of the prawn, in which the male may reach a total length of 320mm, while the female is 250mm (New, Tidwell, D'Abramo, & Kutty, 2009). The giant freshwater prawn culture has tremendously expanded in several countries of the world in the recent decade (Abdolnabi, Ina-Salwany, Daud, Mariana, & Abdelhadi, 2015). The global production of the prawn has risen to 444,000 tonnes in 2009, valued at USD 2 billion (New & Nair, 2012).

In Malaysia, the giant freshwater prawn is called 'Udang Galah' (Iliyasu, Mohamed, & Terano, 2016). This species of the prawn has drawn much attention because of its generous size, its ability to resist diseases, and its high demand both in the local and international markets. Apart from contributing to the national economic development, prawn farming provides employment, income, and food protein for the rural communities in Peninsular Malaysia. From the statistics record of the Department of Fisheries (DoF, 2016) the production of prawns in Malaysia was 281 tons in 1998; it increased to 653 metric tons in 1999, and by the year 2000 it rose to its peak with 1338 metric tons. After the year 2000, production dwindled. The year 2006 experienced a great decline to 194 metric tons, and by 2014 the production was at 398 metric tons. This decline in production could be attributed to inadequate understanding of land factors, including physio-chemical and topographic conditions, soil, water, climatic, and the socio-economic characteristics affecting the suitability of the site for prawn

farming (Iliyasu et al., 2016; Liong, Hanafi, Merican, & Nagaraj, 1988). The giant prawn farming industry has an immense potential, particularly given the valuable feature of accessible favourable natural environments, such as ponds, rivers, lakes, loamy soil, suitable climate, and species' nativity to the country.

Previous studies have not examined land suitability factors from the local knowledge. Hasnita et al. (2015) looked at the constraints for farming prawns in Malaysia and found that the farmers were constrained due to their socio-economic background, despite the natural potential of prawn farming. Iinuma et al. (1999) examined the technical efficiency of carp pond farming in peninsular Malaysia, revealing that carp farming was affected by the seed ratio per ha, labour, feed ratio, and the extensive farming method practiced, which intensive and the semi-extensive methods were found to be more efficient in the carp farming in Peninsular Malaysia. Iliyasu et al. (2016) investigated the factors affecting the technical efficiency of cage fish culture in Peninsular Malaysia and observed that production and feed costs were increasing; therefore, farmers abandoned fish farming for other occupations, leading to declining production. Despite the Malaysian government's financial and input supports to the prawn project, specifically, and fish farming, in general, prawn farming is still facing challenges, and some farms were closed or abandoned. Thus, this study is meant to bridge the knowledge gap by examining land factors affecting the prawn production from the indigenous or local perspective. Therefore, the purpose of this study is to identify the land factors that determine the suitability of a site for giant freshwater prawn (*Macrobrachium rosenbergii*) farming in Negeri Sembilan of Peninsular Malaysia through the local knowledge.

MATERIAL AND METHODS

This section presents the methodologies used for the study. It comprised the study area and sampling, data collection and source, weightages assigned to the land suitability factors for prawn farming and the specification of the model applied for analysis.

The Study Area

Negeri Sembilan is located at latitude 2^0.43' 54.5268" N, and longitude 102^0.15' 9.0072" E, covering a land area of 6,645km square in the Western Peninsular Malaysia with the capital in Seremban (Figure 1). The state is bounded by the states of Selangor at the northeast, Pahang at the north Johor at the east, Melaka in the South, and the South China Sea at the west, with a population of over 1.7 million in 2016, according to statics department of Malaysia.

Sampling Technique and Sample Size

A three-stage sampling technique was applied to select the respondents based on the concentration of prawn farming activities in the study area. Five out of the seven districts were purposely selected comprising Seremban, Port Dickson, Kuala

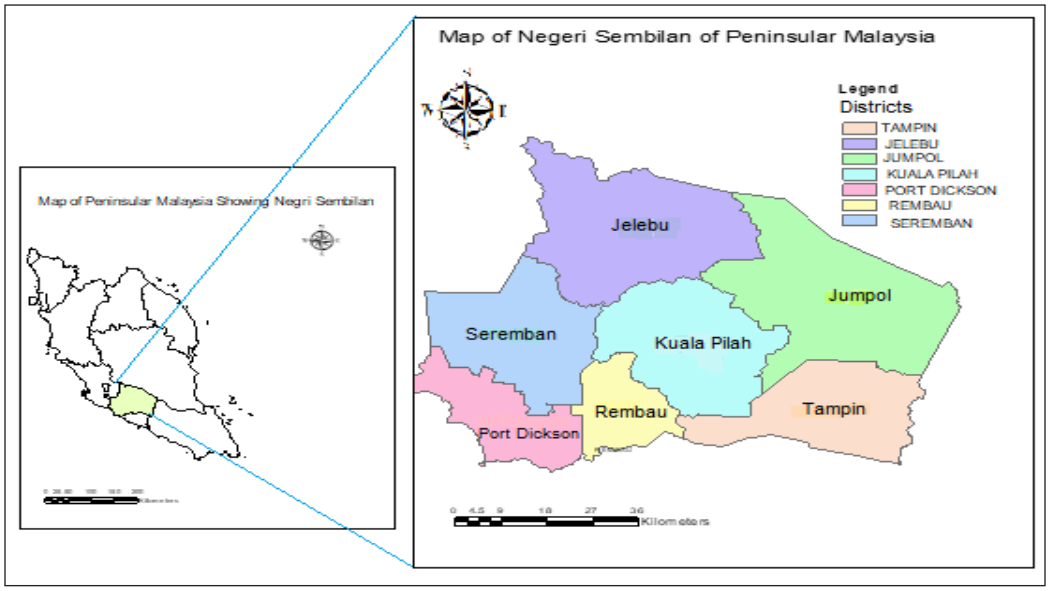


Figure 1. Map of Peninsular Malaysia showing Negeri Sembilan

Pilah, Rembau, and Jelebu as presented in Table 1. From each of the five districts five major prawn producing cells were randomly selected. From each of the cell, 3 prawn farmers who were involved in prawn farming were randomly selected for the study, giving a total of 75 respondents. Ten fisheries officers from the study area were selected for interview.

The descriptive survey approached was used for this study. The sampled population used for the study includes 75 prawn farmers and 10 fisheries officers from the study area as key informant, giving a total study population of 85. Since some of the farmers were not present during research and others abandoned farming, 64 farmers were contacted. Therefore, the study sample

Table 1
List of the sample districts and the respondents

S/No	District	Number of cells per district	Number of farmers per cell	Number of respondents per district
1	Seremban	5	3	15
2	Port Dickson	5	3	15
3	Kuala Pilah	5	3	15
4	Rembau,	5	3	15
5	Jelebu	5	3	15
	Fisheries officer			10
	Total			85

size is 74 people. The respondents for this study were obtained from the list of prawn farmers from the Department of Fisheries regional office Negeri Sembilan, Malaysia. The questionnaires method was used to collect the relevant data from the prawn farmers while informant interviews were conducted with the fisheries officers. To establish the measure of relationships and find meaning, descriptive, correlation and multiple regression statistical analysis were used.

Data Collection and Source

The data for this study was collected via questionnaires and oral interviews from the sampled farmers on their knowledge of the land factors affecting the prawn farming. The observation of the researchers was used to complement the information gathered. Informant interviews were conducted with the fisheries officers to elucidate answers where the farmers' knowledge was limited. To validate the questionnaires, a pilot study was carried out, such that all the necessary corrections and adjustment were made on the questionnaires with the aid of an expert in the field of land analysis from the Department of Geography, Faculty of Arts and Social Sciences, University of Malaya. The pilot study was conducted with five prawn farmers and three fisheries officers to test the validity and reliability of the questionnaires. Regarding the validity, corrections occurred on some of the questions for which the respondents were not certain of the exact responses required. For the reliability, the responses were coded and entered using the SPSS 23 model software, generating a reliability coefficient of 0.851; therefore, they are considered reliable. The reliability test was shown in Table 2. Subsequently, a total of 75 questionnaires were administered to the prawn farmers, although only 64 questionnaires were used for the analysis due to non-responses by some prawn farmers. All ten fisheries officers targeted responded to the interview in their offices. This represented 87.1% of the respondents, considered a very good response rate for making references (Denscombe, 2014) (Table 3).

Table 2
Reliability test

Cronbach Alpha	Cronbach Alpha base on Standardised items
0.842	0.851

Table 3
Target population and response rate

	Response frequency	Target respondent	Percentage
Prawn farmers	64	75	85.3
Fisheries officers	10	10	100
Total	**74**	**85**	**87.1**

Weightages Assigned to the Land Suitability Factors for Prawn Farming

A proforma with a list of 22 factors was prepared to find out the weightage of the land suitability factors having a higher influence on prawn farming in the study area. A five-point "continuum of importance" was made to rate each factor: least important =1, less important =2, important =3, more important =4, and most important =5. These proforma were given to 10 officers from the Department of Fisheries, with the request to rate and assign weightage for each factor in terms of its degree of importance for most suitability for prawn farming. The average mean score for each factor was calculated based on the responses of the officers. The mean score was tabulated and rank was given in the descending order beginning with the highest score. The factors with first to the twelfth rank were chosen for the study. These factors were regrouped to suit the three main categories of water qualities (distance to sources of water, water temperature, water pH, and distance to source of pollution), soil characteristics (land use type, slope, elevation, and soil texture) and infrastructure facilities (distance to roads, distance to market, distance to electricity, and distance to fry source) factors. Table 4 shows the ranks and the corresponding weightages attached to each factor.

Table 4
Prawn farming suitability factors for the study

Factors	Weightages	Ranks
Land use type	4.10	1
Distance to market	4.10	2
Water temperature	3.70	3
Distance to water source	3.60	4
Slope	3.50	5
Elevation	3.50	6
Distance to electricity	3.30	7
Soil texture	3.20	8
Distance to pollutant source	3.20	9
Water pH	3.00	10
Distance to road	2.90	11
Distance to fry	2.70	12

Specification of the Model

This study uses the correlation analysis and multiple regressions to estimate the factors affecting prawn farming in Negeri Sembilan of Peninsular Malaysia. They are mathematically expressed as follows:

$$Y=\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \quad (1)$$

Where

Y= Prawn farming suitability (dependent variable)

β0= Constant term

X1= Water qualities factors

X2= Soil characteristics factors

X3= Infrastructure facilities factors

ε= error term

This equation (β0 + β1 X1 + β2 X2 + β2 X2 + β3 X3) expresses the mean value of the land factors affecting prawn farming for a specific value of water qualities, soil characteristics, and infrastructure facilities. The error term (ε) defines the features by the difference between each individual value of land factors affecting prawn farming suitability and their expected

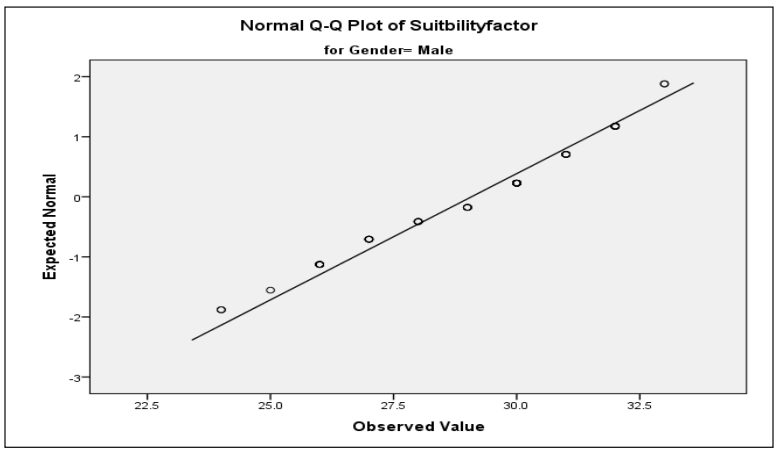
values. To determine the regression model, the coefficient of determination R^2 of the independent variables most be calculated. The R^2 always lies between 0 and 1. The closer the R^2 to 1 the better is the model and it prediction.

RESULTS AND DISCUSSION

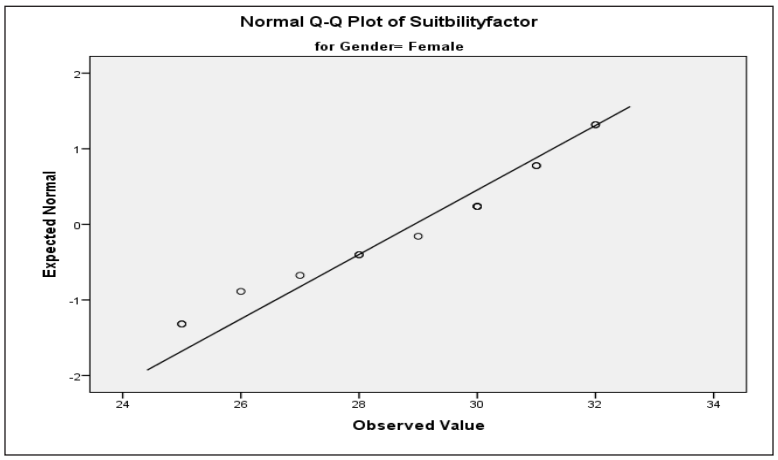
The study was aimed to examine the factors that influence the suitability of land for prawn farming in Negeri Sembilan of Peninsular Malaysia through the farmers' indigenous knowledge.

Test of Normality

The Shapiro-Wilk's test ($p>.05$) and a visual inspection of their histogram, normal Q-Q plot (Figure 2(a) and (b), and box plot show that the land suitability factors data for prawn farming were approximately



(a)



(b)

Figure 2. (a) Q-Q plot for males of land suitability factors for prawn farming; and (b) Q-Q plot for females of land suitability factors for prawn farming

normally distributed for both male and female farmers, with a skewness of -0.353 (SE = 0.340) and a kurtosis of 0.759 (SE = 0.668) for the males, and a skewness of -0.484 (SE = 0.580) and a kurtosis of -0.906 (SE = 1.121) for the females

Demographic and Socioeconomic Characteristics

Table 5 indicates that most of the farmers were male, comprising 76.6 % of the respondents, while 23.4% were female; 87.5% were married. This shows that there were few women prawn farmers, which could be attributed to the socio-cultural feature of the locality. 21.9% were aged between 25 to 44 years old, 50.0% fall between 45-64 years, while 28.1% were 65 years and above. This indicated that prawn farming ventures were managed by the middle-aged citizen. Most of the farmers (85.9%) have formal education, ranging from primary certificate to university degree certificates, which were considered very relevant for adapting to new prawn farming technology (Uaiene, Arndt, & Masters, 2009). Only 14.1% of the farmers were without formal education. Prawn farming experience ranged from 1-5 years (1.6%), 6-10 years (25.0%), 11 years and above (18.8%), indicating that most of the farmers had experienced prawn farming. About 59.4% practiced prawn farming as a primary occupation, while about 75.0% combined prawn farming with other agriculture practices. Lands for farming were acquired through family heritage (57%), leased land (35.9%), and state land (6.3%). The 64 prawn farmers' ponds were also analysed; the average pond area was 0.36 ha for all sample farms. 76.6% of the farms had a pond area of less than 0.60h; the entire farm size of prawn ponds in Negeri Sembilan was somewhat small (Ang, 1990; Banu, Siraj, Christianus, Ikhsan, & Rajaee, 2015). The average prawn production was 1500 kg/ ha per annum (64.1%) for all sample farms.

Table 5
Demographic and socioeconomic characteristics of farmers

Variables	Frequency	Percent (%)
Farmer's Age		
25-44	14	21.9
45-64	32	50.0
65- above	18	28.1
Total	**64**	**100.0**
Gender		
Male	49	76.6
Female	15	23.4
Total	**64**	**100**
Level of education		
No. education	9	14.1
Pri/Sec. educ.	15	23.4
Dip/HND	21	32.8
Graduate	19	29.7
Total	**64**	**100**
Marital status		
Not married	8	12.5
Married	56	87.5
Total	**64**	**100**
Prawn farming Occupation		
Primary occupation	38	59.4
Secondary occupation	26	40.6
Total	**64**	**100**
Years of experiences as prawn farmer		
Less than 1 year	1	1.6
1-5 years	16	25.0
6-10 years	35	54.7
11 years above	12	18.8
Total	**64**	**100**

Table 5 *(continue)*

Variables	Frequency	Percent (%)
Pond size		
Less than 0.2ha	4	6.3
0.2 -0.5ha	45	70.3
0.6 and above	15	23.4
Total	**64**	**100**
Combine prawn with other Agricultural practice		
No	16	25.0
Yes	48	75.0
Total	**64**	**100**
Sources of land		
Family land	37	57.8
Lease land	23	35.9
State land	4	6.3
Total	**64**	**100.0**
Quantities of prawn produce in a year per hectare		
Less than 1000kg/ ha/yr.	7	10.9
1000kg/ha/yr. - 1500kg/ha/yr.	41	64.1
1500kg/ha/yr. above	16	25.0
Total	**64**	**100.0**

Soil Characteristics

Table 6 presented the soil characteristics factors. Soil type of the sample prawn farm ponds were composed of 54.7% loam, most suitable for prawn farming; 31.3% clay; and 14.1% sandy, not suitable for prawn ponds. Regarding slope of land suitable for prawn farming, 76.6% preferred flat land, with a gentle slope between 0-5% considered most suitable for prawn farming, 20.3% land had a moderate slope, while 3.1% had high slopes. Similarly, 75.0% farm ponds were situated in low elevation of about 2-2.5 meters, considered as most suitable for prawn farming; 18.8% were situated on medium elevation between 4-5 meters; and 6.3% were situated on either very high (>5m) or too low (<1m) elevation. For suitable land use types, 62.5% preferred agriculture/ aquaculture land, 34.4% grassland/bare land, and 3.1% suggested mangrove forest/ residential areas.

Table 6
Soil characteristics

Variables	Frequency	Percent (%)
Land use type		
Agriculture/ Aquaculture land	40	62.5
Grassland/bare land	22	34.4
Mangrove forest/ residential areas	2	3.1
Total	**64**	**100**
Slope		
Gentle slope flat land (0-5%)	49	76.6
Moderately slope (5–15%)	13	20.3
High slope (above 15%)	2	3.1
Total	**64**	**100.0**
Elevation		
Low elevation (2–2.5m)	48	75.0
Medium elevation (4–5m)	12	18.8
High elevation or too low (more than 5m or less than1m)	4	6.3
Total	**64**	**100.0**
Soil texture		
loam	35	54.7
Clay	20	31.3
sand	9	14.1
Total	**64**	100.0

Water Quality

Water quality factors are presented in Table 7. The major sources of water for prawn ponds were 50.0% from streams/rivers, 34.4% from springs and other underground water sources (bore holes and wells) and 15.6% from rainwater. Sources of water pollution were found to be dominated by agriculture farm pesticide (46.9%), rain water erosion (21.9%), domestic waste discharge (15.6%), and industrial waste discharge (15.6%). The water temperature was dominantly moderate at (54.7%, high at 32.8%, and low at 12.5%. Water pH of less than 4ppt or greater than 9ppt dominated, with 57.8%. 29.7% of farmers recorded the pH of 4-5ppt to 8-9ppt, considered moderately suitable for prawn farming; 12.5% of farmers recoded the water pH of their farms to 6-7.5 ppt, which was considered most suitable.

Table 7
Water quality

Variables	Frequency	Percent (%)
Water source		
River/streams	32	50.0
Rain	10	15.6
Springs/bore holes/wells	22	34.4
Total	**64**	**100.0**
Source of water pollution		
Industrial discharge	10	15.6
Agricultural waste discharge	30	46.9
Domestic waste	10	15.6
Rainwater erosion	14	21.9
Total	**64**	**100.0**

Table 7 *(continue)*

Variables	Frequency	Percent (%)
Distance to water source		
Less than 1km	44	68.8
2-4km	15	23.4
More than 4km	5	7.8
Total	64	100.0
Did you Measure Temperature and pH of farm pond?		
Every week	17	29.7
Some time	33	51.6
Never	12 33	18.8
Total	64	100
Water temperature		
25–32^{0}c	21	32.8
15–25^{0}c	35	54.7
less than <12^{0}c or greater than > 32^{0}c	8	12.5
Total	**64**	**100.0**
Water pH		
6 – 7 ppt	8	12.5
4–5ppt or 8–9ppt	19	29.7
greater than >9ppt or less than <4ppt	37	57.8
Total	**64**	**100.0**
Distance to source of pollution		
Greater than 4km	22	34.4
between 2- 3km	29	45.3
less than 2km	13	20.3
Total	**64**	100.0

Infrastructures Facilities

Infrastructures facilities (Table 8) considered for the prawn ponds include distance to roads, with about 56.3% farms located within 0-2km from the roads which was regarded as most suitable for prawn farming. 29.7% of farms were located about 2km

to 5km away from roads, while 14.1% of farms were located above 5km from the main roads. Farm ponds with accessibility to electricity sources within 0 to 2 km were 59.4%, with farms located within 2 to 5km at 34.4%, and farms located above 5km away at 6.3%. Regarding market accessibility and proximity, about 45.3% were located within 0 to 2km from the market, 34.4% located within 2- 5km from the market, and the remaining 20.3% farms were located more than 5km away from the market. About 71.9% of the farmers travelled for more than 12km to access post larva (fries) from the neighbouring state hatcheries, 20.3% travelled for 5 to 12km, while 7.8% travelled within 5km or within their farms to access their fries or seeds.

Infrastructural facilities and socio-economic features have major influences on the farms. That is, if all the natural conditions were made without the infrastructures, the farms would not yield any satisfactory results. Farmers added that the infrastructure factors (50%) rank first, before water (35%) and soil (15%) when it comes to ranking the preference of factors affecting prawn farming (Table 9).

Table 8
Infrastructures facility

Variables	Frequency	Percent (%)
Distance to road		
within 0 - 2km	36	56.3
2km to 5km	19	29.7
above 5km	9	14.1
Total	**64**	**100**
Distance to electricity		
within 0 - 2km	38	59.4
2km to 5km	22	34.4
above 5km	4	6.3
Total	**64**	**100.0**
Distance to market		
within 0 - 2km	29	45.3
2km to 5km	22	34.4
above 5km	13	20.3
Total	**64**	**100.0**
Source of prawn Seeds		
Institution's industries	26	40.6
Commercial seed producers	16	25.6
Own hatchery	9	14.1
Other farmer own farms	6	9.4
Wild	7	10.9
Total	**64**	**100**
Distance to hatcheries		
Less than 5km	5	7.8
Between 5–12km	13	20.3
More than 12km	46	71.9
Total	**64**	100.0

Table 9
Overall level of influence

Factors	Frequency	Percentage (%)
Water	22	(35%)
Soil	10	(15%)
Infrastructure	32	(50%)
Total	**64**	100%

Prawn Farming Suitability

From Table 10, the respondents indicated that sources of water (2.61 mean), water temperature (2.20 mean), water pH (1.55 mean), water pollution (2.14 mean), land use

Table 10
The mean land factors affecting the land suitability of prawn farming

Land Factors Affecting prawn farming suitability	N	Mean	Standard Deviation
Sources of water	64	2.61	.633
Water temperature	64	2.20	.647
Water pH	64	1.55	.711
Water Pollution	64	2.14	.732
Land use	64	2.59	.555
Slope	64	2.80	.406
Elevation	64	2.81	.393
Soil Texture	64	2.34	.761
Dist. to roads	64	2.42	.730
Dist. to market	64	2.25	.777
Dist. to electricity	64	2.53	.616
Dist. to fry	64	2.80	.406

(2.14 mean), slope (2.80 mean), elevation (2.81 mean), and soil texture (2.34 mean) had effects on the suitability of land for prawn farming. The infrastructural facilities, including distance to road (2.42 mean), distance to market (2.25 mean), distance to electricity (2.53 mean), and distance to hatcheries (2.80 mean), which were the socio-economic characteristics, were indicated by farmers to have a major influence on prawn farming, because if the water and soil conditions were not good, prawn farming could not yield any reasonable results.

From the interviews, the respondents indicated that accessibility and lack of quality fries (post larvae), water acidity and pollution, and lack of capital had been a major problem attributing in the declining prawn production. To improve prawn production, the pond's water has to be drained to apply lime on the ponds. Farmers also need training on prawn ponds management and a credit facility to facilitate production.

The Correlation Analysis

Factors were correlated by applying the Pearson correlation analysis at a significance level of 0.05 to determine the relationship (Table 11). The results show that there is a significant positive relationship between water quality and the suitability of prawn farming, with correlation $r(62) = 0.669$, $p=0.000$ values. This confirms what New (2002) observed in his study, that quality and adequate water supply to fill the ponds is suitable for prawn farming and survival. The water quality component may include the accessibility of water free from pollution and low acidity level with maximum temperature (Hossain & Das, 2010; Rekha et al., 2015). The soil quality factor had a positive correlation with prawn farming suitability with $r(62) = 0.559$, $p = 0.000$ values, which agreed with Hadipour, Vafaie, and Hadipour (2015), that the soil had enormous potential for prawn farming; the slope, the elevation, and the texture determine the ability of the land to hold water

Table 11
Pearson correlation variables

Prawn farming suitability N=64			
Water quality	Pearson correlation	0.669**	
	Sig. (2 tailed)		0.000
Soil quality	Pearson correlation	0.559**	
	Sig. (2 tailed)		0.000
Infrastructure facility	Pearson correlation	0.566**	
	Sig. (2 tailed)		0.000

**Correlation is significant at the 0.01 level (2-tailed)

and supply nutrients to the pond. Also, it agrees with Faruque et al. (2017) and Haque et al. (2016) that soil quality will determine where and whether to farm prawn. The infrastructure factor has the highest positive relationship of $r(62) = 0.566$ with $p = 0.000$ values, with prawn farming suitability. This agrees with the study by Santos, Aubin, Corson, Valenti, and Camargo (2015), that infrastructure plays a vital role in prawn farming, that an inadequate infrastructure facility resulted in failure in many extensive prawn farming. Ahmed and Flaherty (2013) agreed with this stand, that infrastructure played some key role, but water and the soil factors determined the farming of prawn in a region. All factors have an important relationship ($p<0.05$) with prawn farming. The inferential statistics are applied to reach a reasonable conclusion and infer from the data the opinion of the population and what they think of the probability that the land factors affecting the suitability of prawn farming are reliable.

Regression Analysis

Multiple regression analysis was carried out to measure the influence of the independent variables (water quality, soil characteristics, and infrastructure facilities factors) on the dependent variable (prawn farming suitability). The coefficient of determination $R^2 = 0.951$, meaning that 95.1% of suitability is affected by the independent variables, and that there are other factors not included in the model that affect prawn farming suitability (Table 12).

To determine the regression model, the coefficients of the independent variables indicated that water quality (0.563), soil characteristics (0.528), and infrastructure facilities (0.533) were the constant (0.499)

Table 12
Regression analysis

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
	0.975[a]	0.951	.948	.573

a. Predictors: (Constant), Infrastructure Facilities, Soil Characteristics, Water Qualities

Table 13
Coefficients[a]

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.499	0.924		0.540	
Water qualities	0.990	0.051	0.563	19.558	.000
Soil characteristics	1.019	0.055	0.528	18.467	.000
Infrastructure facilities	1.153	0.062	0.533	18.526	.000

a. Dependent Variable: Prawn Production

(Table 13). The regression model is represented as: $Y= 0.499 + 0.563x1 + 0.528x2+ 0.533x3 + \varepsilon$

From the study, giant freshwater farming was greatly affected by the water quality, soil characteristics, socio-economic, and infrastructure factors. Water and soil qualities proved to affect the prawn production; the water quality and quantity must be reasonable enough to farm prawn in the pond. Water pH of 7.5 ppt to 8.5ppt was established to be the most suitable for prawn farming. The soil texture and the land slope determined the prawn production from the study area. Soil with good clay content was adequate to hold water; land with a gentle or flat surface was confirmed by all farmers to be suitable for prawn pond constructions. On the infrastructure factors, distance to a source of fries plays a significant role; where hatcheries are located far from the farm, mortality of the fries increases dramatically. Distance to roads and markets were other factors, as lack of accessibility means lower yield and less profit. Farms located near roads and markets have a great prospect for higher production because demand and transportation of farm products and other inputs to and from the market is faster. Electricity supply as a factor has a major influence on prawn farming. Efficient electricity is needed to power the farm machines.

CONCLUSION

Descriptive statistics, the Pearson correlation analysis, and the multiple regression analysis were applied to estimate the factors affecting the land suitability for prawn farming in Negeri Sembilan, via the farmers' local knowledge. The prawn production data and other valuable information in the survey are analysed.

The correlation analysis indicated that there are positive relationships between all independent variables of water quality factors, soil quality factors, and infrastructural facilities factors on the dependent variable of prawn farming considered in the study area. This finding is consistent with the fact that the water quality, soil characteristics, and infrastructural facilities have impacts on prawn farming (Hossain & Das, 2010; New & Nair, 2012). It was indicated from the study that infrastructural facilities, which were

also a socio-economic feature, ranked first before water and soil characteristics when considering their influence on prawn farming.

In this study, 64 prawn farmers and 10 key informants were used to examine the influence of the various land factors that affect prawn farming in Negeri Sembilan of Peninsular Malaysia. This study recommends among other methods that can be explored further is the addition of multi-criteria evaluation techniques to this analysis of land factors for determining suitable site for prawn farming through the local knowledge system in the study area.

ACKNOWLEDGEMENT

The authors would like to acknowledge UM IPPP grant Number HIR- MOHE funding project: H-23001-G000006 and Centre of Biotechnology for Agriculture, CEBAR, University of Malaya, Malaysia. The authors have no any conflict of interest or any institution related to this manuscript.

REFERENCES

Abdolnabi, S., Ina-Salwany, M., Daud, H., Mariana, S., & Abdelhadi, Y. (2015). Pathogenicity of Aeromonas hydrophila in giant freshwater prawn Macrobrachium rosenbergii, cultured in East Malaysia. *Iranian Journal of Fisheries Sciences, 14*(1), 232-245.

Ahmed, N., & Flaherty, M. S. (2013). Opportunities and challenges for the development of prawn farming with fish and rice in southeast Bangladesh: potential for food security and economic growth. *Food security, 5*(5), 637-649.

Ang, K. (1990). Status of aquaculture in Malaysia. *Aquaculture in Asia. Asian Fisheries Society, Indian Branch, Mangalore*, 265-279.

Banu, M. R., Siraj, S. S., Christianus, A., Ikhsan, N. F. M., & Rajaee, A. H. (2015). Genetic variation among different morphotypes of the male freshwater prawn *Macrobrachium rosenbergii* (De Man). *Aquaculture Reports, 1*, 15-19. doi: http://dx.doi.org/10.1016/j.aqrep.2015.02.001

Calvo-Iglesias, M. S., Crecente-Maseda, R., & Fra-Paleo, U. (2006). Exploring farmer's knowledge as a source of information on past and present cultural landscapes: A case study from NW Spain. *Landscape and urban planning, 78*(4), 334-343.

Chambers, K., Corbett, J., Keller, C., & Wood, C. (2004). Indigenous knowledge, mapping, and GIS: a diffusion of innovation perspective. *Cartographica: The International Journal for Geographic Information and Geovisualization, 39*(3), 19-31.

Denscombe, M. (2014). *The good research guide: For small-scale social research projects*. Berkshire, England: McGraw-Hill Education.

DoF. (2016). Annual fisheries statistics of Malaysia, 2014. Putrajaya, Malaysia: Ministry of Agriculture and Agro-allied Industries (MoA).

FAO. (1980). Report of the training course on prawn farming for Asia and the Pacific. (F. a. A. Department, Trans.). In V. Soesanto (Ed.), *South China Sea fisheries development and coordinating programme.* Manila, Philippines: FAO.

FAO. (2016). The state of the world fisheries and aquaculture 2016: Food and agriculture organization of the United Nations. Retrieved October 10, 2017, http://www.fao.org/3/a-i5555e.pdf

Faruque, G., Sarwer, R. H., Karim, M., Phillips, M., Collis, W. J., Belton, B., & Kassam, L. (2017). The evolution of aquatic agricultural systems in

Southwest Bangladesh in response to salinity and other drivers of change. *International Journal of Agricultural Sustainability, 15*(2), 185-207.

Hadipour, A., Vafaie, F., & Hadipour, V. (2015). Land suitability evaluation for brackish water aquaculture development in coastal area of Hormozgan, Iran. *Aquaculture international, 23*(1), 329.

Haque, M. R., Islam, M. A., Wahab, M. A., Hoq, M. E., Rahman, M. M., & Azim, M. E. (2016). Evaluation of production performance and profitability of hybrid red tilapia and genetically improved farmed tilapia (GIFT) strains in the carbon/nitrogen controlled periphyton-based (C/N-CP) on-farm prawn culture system in Bangladesh. *Aquaculture Reports, 4*, 101-111.

Hasnita, C., Danial, A. M., Yusrina, A., Dini, R. N., Khairiyah, M., Tan, S., … & Adila, A. F. (2015). Constraint analysis in the farming of giant freshwater prawn (*Macrobrachium rosenbergii*) in peninsular Malaysia. *Advances in Environmental Biology, 9*(27), 182-186.

Hossain, M. S., & Das, N. G. (2010). GIS-based multi-criteria evaluation to land suitability modelling for giant prawn (*Macrobrachium rosenbergii*) farming in Companigonj Upazila of Noakhali, Bangladesh. *Computers and electronics in agriculture, 70*(1), 172-186.

Iinuma, M., Sharma, K. R., & Leung, P. (1999). Technical efficiency of carp pond culture in peninsula Malaysia: An application of stochastic production frontier and technical inefficiency model. *Aquaculture, 175*(3), 199-213. doi: http://dx.doi.org/10.1016/S0044-8486(99)00033-2

Iliyasu, A., Mohamed, Z. A., & Terano, R. (2016). Comparative analysis of technical efficiency for different production culture systems and species of freshwater aquaculture in Peninsular Malaysia. *Aquaculture Reports, 3*, 51-57.

Liong, P. C., Hanafi, H. B., Merican, Z. O., & Nagaraj, G. (1988). Aquaculture development in Malaysia. *In Seminar on Aquaculture Development in Southeast Asia,* (pp. 73-90). Iloilo City, Philippines: SEAFDEC Aquaculture Department.

New, M. B. (2002). *Farming freshwater prawns: A manual for the culture of the giant river prawn (Macrobrachium rosenbergii)*. Marlow, England: FAO.

New, M. B., & Kutty, M. N. (2010). Commercial freshwater prawn farming and enhancement around the world. *Freshwater Prawns; Biology and Farming*, 346-399.

New, M. B., & Nair, C. M. (2012). Global scale of freshwater prawn farming. *Aquaculture research, 43*(7), 960-969.

New, M. B., Tidwell, J. H., D'Abramo, L. R., & Kutty, M. N. (2009). *Freshwater prawns: Biology and farming*. Iowa, USA: John Wiley & Sons.

Rekha, P. N., Gangadharan, R., Ravichandran, P., Mahalakshmi, P., Panigrahi, A., & Pillai, S. (2015). Assessment of impact of shrimp farming on coastal groundwater using geographical information system based analytical hierarchy process. *Aquaculture, 448*, 491-506.

Santos, A. A. O., Aubin, J., Corson, M. S., Valenti, W. C., & Camargo, A. F. M. (2015). Comparing environmental impacts of native and introduced freshwater prawn farming in Brazil and the influence of better effluent management using LCA. *Aquaculture, 444*, 151-159.

Uaiene, R. N., Arndt, C., & Masters, W. (2009). Determinants of agricultural technology adoption in Mozambique. *Discussion papers, 67*. Retrieved October 10, 2017, from http://cebem.org/cmsfiles/publicaciones/Determinants_of_agricultural_technonolgy_adoption_in_Mozambique.pdf