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Ornamental Fish Farming and Spatial Distribution in Layang-Layang Kluang District Using Geographic Information System (GIS) and Remote Sensing

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Abstract: This paper presents a new structure of research in ornamental fish farming among the ornamental fish farmers in malaysia. The potential for further expansion of the industry in malaysia is extensive. however, importing activities are intermittent due to export restrictions made by the european union (eu) from 2015. The objective of this study is to map the 19 ornamental aquaculture farms in layang-layang by creating the compartmentalisation system using geographic information systems (GIS). A total sample population comprised of 19 ornamental fish farmers. Non-spatial data (survey) and spatial data (GIS) were used in the study to capture farm location effect on the farm operational activities especially in fisheries bio-security terms. Descriptive analysis were used to describe the respondent's socio-economic profile. The relationship between fish farming and the independent variables were cross-tabulated and chi-square analysis was used to test the null hypothesis. The integration of both vector and raster data was used to determine the spatial characteristics on farming activities spatially. The descriptive analysis shows that majority of the farmers were male and married. 34.8% aged 41-50 years old and 41.6% had secondary education level, SPM. majority of the respondents with 7 (36.8%) had a farm scale more than 10ha of farm size. Average total production with 2 millions a year. The goldfish (29%) and tiger barb (8%) are most favorable type of fish reared. A very significant relationship between farming activity and age, education level, total of production and income. The spatial analysis shows that the farmers live less than fifteen (15) kilometres from town to house and farm. The spatial database of the compartmentalized farm is the best solutions for eu requirement that help farm monitoring by fisheries bio-security division.

Keywords: Ornamental Fish, Spatial Analysis, GIS, Fisheries Bio-security, off Farm employment.

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1. Introduction

The Malaysia fisheries sector plays a decisive role in its economic development and is also a source of employment, foreign exchange and protein supply for the country's people. Principally, the Malaysian fisheries industry encompasses three (3) main sub-sectors including marine capture fisheries, inland capture fisheries and aquaculture. The fisheries sector in Malaysia is governed by the Department of Fisheries (DOF) under the Ministry of Agriculture and Agro-based Industry (MOA) by the empowerment of Fisheries Act 1985. The DOF is known as the national Competent Authority (CA) responsible for all matters involving live fish, which DOF has jurisdictions over all matters related to live fish. Year 2015 recorded the total landings of marine fish were 1,486.1 thousand tonnes, up 1.9 percent from 1,458.1 thousand tonnes in year 2014 while freshwater aquaculture production increased 5.1 percent to 112.1 thousand tonnes. Thusly, the production of brackish water / saline aquaculture decreased by 4.7 per cent to 394.3 thousand metric tonnes compared to the previous year. In year 2016, the fishery sub-sector produces 2.06 million tonnes of fish, an increase of 3.70 per cent compared to 2015 by 1.99 million tonnes. This production includes marine capture fisheries, land fisheries and aquaculture. In terms of value, it showed an increase of 9.24 per cent over the same period of RM10.1 billion compared to RM9.3 billion in 2015. Thus, in 2016 alone, catchment and aquaculture fields accounted for 1.57 million tonnes and 490,027 tonnes of fish production, with aquaculture 407,403 million tonnes with RM2,784,721. In fact, the overall value of the fisheries industry is RM13 billion a year (Annual Fisheries Statistics, 2017). The five-year strategic agenda of the Ministry of Agriculture and Agro-based Industry in the 11th Malaysia Plan (11MP) is to improve the agro-food industry through modernization and improvement in investment opportunities as well as enhancing marketing.

Ornamental fish culture sector contributed to the global economy with a enormous turnover of billions of dollar yearly. Thus, the ornamental fish keeping is one of the most popular hobbies in the world. This sector has big potential in creating job opportunities besides develop extremely large revenue to national treasury. On the othe hand, the market for ornamental fish in the world for public aquaria is less than 1% at present and over 99 % of ornamental fish market is limited to hobbyist group. Entrepreneurship concept is developed through ornamental fish farming and it is gaining popularity continually. People are progressively entering into the ornamental fish industry especially from African and Asian countries. The top exporting country is Singapore followed by Hong Kong, Malaysia, Thailand, Philippines, Sri Lanka, Taiwan, Indonesia and India (Shabir Ahmad Dar et.al.,2018). The ornamental industry in Malaysia is

doing well until the issuance of non-compliance with a requirement, standard, or procedure needed. CAR was received based on the DG (SANTE) / 2015-7562 audit on 09th March to 17th March 2015 specifically, in monitoring the assess of health control on aquaculture animals in aquaculture farms for export purposes. Which later, lead to the import restrictions by the European Union (EU) against the Department of Fisheries Malaysia. Therefore, this restriction has negatively affected the breeders and the value of exports of the country. Fisheries Bio-security Division (FBD) was established to control and manage fish health and food safety, particularly for fish and fishery products. In order to escape from EU sanctions, FBD carry out the role of fishery bio-security in responsding to an EU-issued audit using the Geographic Information System (GIS). Bio-security or "hazard reduction through environmental manipulation" (Plumb, 1992), is often defined as practices that reduce the number of pathogens that enter a facility. Bio-security is the concept of protecting culture animals from contamination by diseases and of preventing the spread of diseases across boundaries, has become increasingly important with the intensification of aquaculture production systems (Sachin O. Khairnar, et.al.,2018). Particularly, the objective of this study is to examine the spatial characteristic variables in terms of management of aquatic animal health of 19 ornamental aquaculture farms in Layang-layang by creating the compartmentalisation system using GIS spatial analysis, hoping that at the end of this project, Malaysia will be free from the import restrictions on ornamental fish and this paper will focus on on-farm employment, spatial characteristics and off-farm employment of the ornamental fish farmers in the Layang-layang district. Ruslan et al., (1998) claimed that in order to identify the farmers, farm and spatial variables of farming activities, it needs a lot of precision and well managed and updated data gathered from various sources. This can be done with a simple database. With the development of GIS, we will be able to insert, manage, manipulate, analyse and present data related to geography or spatial completely. Hence, Ruslan et al. (1998) found that both spatial and non-spatial data are important in the GIS and must be updated precisely to make it valuable to the user.

2. Literature Review

2.1 Ornamental Fish and the Industry

Aquaculture sector is currently the fastest growing food sector in the world, and the open oceans are seen as one of the most likely areas for large-scale expansion (Lovatelli, Aguilar-Manjarrez, & Soto, 2013; Rubino, 2008). Thus, ornamental fishes commonly mean attractive colourful fishes of various characteristics, which are kept as pets in confined space of an aquarium or a garden pool for fun and

recreational purposes. Ornamental fishes are usually kept in aquarium and therefore known as Aquarium Fishes. These living jewels need not always have bright colours; as sometimes their unique characteristics such as body colour, morphology and apparently, mode of taking food may also add to their attractiveness. Ornamental fish bring about more revenue for countries that deal on it. The world's largest market for ornamental fish are The United State (US) and the European countries. Ornamental fish has alluring colours and they are mostly the size is small. This fishes exhibit wonderful array and have different methods of breeding. Their behaviors and life span are varies from one species to the other and can be found in brackish water, salt water and fresh water. Although exact figures on the value and trade of the ornamental fish industry do not exist, the value of ornamental fish and invertebrates imported into different countries worldwide is approximately around $278 million US dollars (FAO 1996-2005). However, the greatest volume or number of individuals in the trade, at average of 90-96%, are of freshwater origin and are produced in commercial aquaculture facilities (Chapman 1997; Cato and Brown 2003). Most of the ornamental fish is sourced from developing countries in the tropical and sub tropical regions. Hence, the international trade in ornamental fish in fact, provides employment opportunities for thousands of rural people in most developing countries. As a result of advancements in breeding, transport and aquarium technology, more and more species are being added every year (V K Dey, 2016).

2.2 Socio-economic and Livelihood Profile of Ornamental Fish Producers

Usually, the trade in ornamental fish is a multi-million dollar business with more than one hundred countries involved worldwide. For many rural communities in Africa, South America and South East Asia, the industry are an important source of overseas income. In view of the former, some research groups have changed their aquaculture activities from food to ornamental fish. The Department of Ichthyology and Fisheries Sciences at Rhodes University, Republic of South Africa, had concentrated its efforts in the past on the culture of food fish, but has switched its focus towards ornamental fish, as they believe that "it was better to create jobs in paying businesses so that people can buy food, than to try and develop 'cheap' protein sources and never elevating people's standard of living" (Stallard, 1994). Currently, there are about 259 ornamental fish exporters in Malaysia (Department of Fisheries, 2016). The collection, breeding and marketing of ornamental fishes is a sizable industry that generates jobs and foreign exchange. But, there are concerns over the economic viability and ecological sustainability of the industry. Further, Ayyappan and Krishnan (2004) found in their study that the fisheries sector contributes to the livelihood of a large section of the economically underprivileged population. In some areas, such as

South America, the selling of these fish represent the sole income of often impoverished families (Chao, 1995a).

Indeed, the prospects of ornamental fisheries have been emerging substantially as a lucrative horizontally integrated commercial aquaculture venture. Though, the ornamental fish keeping which started as a hobby across the world, owing to its burgeoning demand in national and international markets, has turned out to be a commercially traded commodity in different parts of the world (Ukaonu et al. 2011). Thus, it has been estimated that over 1.5 million people are engaged in this sector, and over 3.5 million hobbyists constitute the trade in the world (Dey, 2010). The ornamental fish sector has been recognized for its ability to generate employment opportunities, alleviating poverty and contributing to the growth of national income by enhancing foreign exchange earnings. With the phenomenal increase in the demand of ornamental fishes worldwide, more countries have realized the economic potential of this sector and intervened directly to promote its development (Lee, 2005).Ornamental fish culture has made a paradigm shift among entrepreneurs ushering in economic development. Production of animals for the aquarium hobbyist trade is a rapidly growing sector of the aquaculture industry, and it will continue to become more important as restrictions are placed on collecting animals from the wild (Tlusty, 2001). It is quite clear that the global ornamental fish industry has been growing steadily over the years, and an increasing number of entrepreneurs are becoming interested in the trade (Gurumayum and Goswami, 2002). Moreover, the ornamental fish trade is a booming business across the globe, and the ancillary activities associated with the sector such as supplementary feed, medications and manufacturing of chemicals and providing aquarium support services provides opportunities of business for breeders, farmers, aquarists and other people (Itzkovich, 2011). Thus, it is important to understand the current livelihood patterns of the people involved in this sector. Livelihood does not only mean the activities that people carry out to earn a living but also the different elements that contribute to or affect their ability to ensure a living for themselves which includes the assets that enable them to gain access to human, natural, social, financial, physical capital and its use to satisfy basic needs (Messer and Townsley, 2003).

2.3 Fisheries Bio-security and Fisheries Biosecurity Division

Ornamental plants and animals that are accidentally or purposely released into the wild can establish reproducing populations, often with disastrous impacts on native aquatic ecology. Once established, aquatic pests can be very difficult, if not impossible to be destroyed. This is where the needs of bio-security element existed. Thus, Bio-security is a set of the practices and procedures used to prevent the introduction, emergence, spread, and persistence of infectious agents and disease within and around fish

production and holding facilities. In general terms, it is a strategic and integrated approach to analyzing and managing relevant risks to fish health and associated risks to the environment. These practices help eliminate conditions that can enhance disease susceptibility among the fish and applicable to all levels of the ornamental fish industry, producers, wholesalers, retailers and last but not least, the hobbyists. Year 1995, DOF became a member of the World Trade Organization (WTO). Thus, Malaysia had also ratified the Sanitary and Phytosanitary (SPS) Agreement that was designed to protect human, animal and plant life or health in its member countries. FBD is mandated to ensure that the spread of fish diseases is contained and that fish and fishery products are free from contaminants for safe consumption. In achieving these objectives, FBD conducts activities including official control, official analysis and official guarantee at the primary production of the supply chain, such as in aquaculture farms, fishing vessels, feed mills and fish meal manufacturing plants (Hemalatha R. S., 2014).

2.4 Geographic Information System (GIS)

GIS may be determined as the integration of computer and software with spatially referred digital data so that storage, retrieval, manipulation, analysis stages and display all forms of geographically referenced information. GIS is a computer assisted system that can input, store, retrieve, analyse & display geographically referenced information useful for management's decision making. Thus, GIS is a toolbox to analyze spatial data. Burrough (1986) defined GIS as one of powerful data set designed to gather, store, make changes and transformation and show reality data in spatial base. Clarke (1995) defined that GIS is a computer system used for the purposes of gathering, storing, regaining, analyzing and presenting spatial data. Therefore, it can be concluded that GIS is a tool that created to solve special matters. The usage of GIS in social science still scanty but has a big potential especially in fisheries monitoring. Thus, studying demographic research using GIS is referring to two different phenomena in a same geographical spatial location, including individuals as a phenomenon and other type of phenomena such as house, farm, road, river or forest that stays evenly in geographic spatial. The individual people data will be integrated with other spatial object for an example the home address or small unit of survey data. It is different compared to physical objects such as a roads, as it's difficult to predict the real location of an individual person.

Otherwise, the complete and reliable database is the most important component in GIS where GIS covers the data model attribute and spatial data. Clarke (1997) claimed that GIS could integrate the attribute data model and spatial data model which later on can be integrated with sharing ID. Without a reliable database, GIS is useless. The ability of analysing and visualizing the agricultural environment and workflows in the GIS has proven to be very beneficial to the farming industry. On the other hand, GIS

plays an important and increasing role in the agricultural production throughout the world by helping farmers to increase their farm production, reduce farm costs and manage their land more efficiently at the same time.

2.5 Spatial Distribution, Distance Characteristics and Off-Farm Employment

The important part of this study is to create a simple database that could help in identifying the distribution of on and off-farm employment by doing spatial analysis using GIS and statistics analysis using SPSS software. GIS is a technological field that incorporates geographical features with tabular data in order to map and analyse assess real-world problems. Coupled with this data is usually tabular data known as attribute data. Attribute data generally defined as additional information about each of the spatial features. An example of this would be location of off-farm employment. The actual location of the off-farm employment is the spatial data. Additional data such as the farmer's name, level of education and total number of dependants would make up the attribute data. It takes the partnership of these two data types that enables GIS to be such an effective problem solving tool through spatial analysis. The real power in GIS is through using spatial and statistical methods to analyse the attribute and geographic information. The end result of the analysis can be derivative information, interpolated information or prioritized information (Amod Ashok Salgaonkar, et.al., 2018).

Location-specific information of an ornamental fish farm for an entire region is best handled by a computerized information system such as GIS, where the software provides tools for the display and analysis of spatial information Starr and Estes (1990). It stores geographic data, retrieves and combines the data to create a new representation of geographic space, provides tools for spatial analysis, and performs simulations to help experts organize their work in many areas including transportation and agricultural development (Rigaux et al., 2002). Locations, geographically, however does affect the decisions of farmers or households to join off farm activities. Leeuwen et al. (2008) analysed the importance of off-farm activities in distinctive regions in the Netherlands and possible effects on the efficiency of agricultural policies. The result shows that the location of farm households along the spatial gradient affects resource availability and farmers' livelihoods. The GIS displays and analyses socioeconomic data that could aid many social researchers in understanding socioeconomic reality influenced by geographical positions. Research done by Bhatta (2010); Bhatta and Doppler (2010) showed that the variations in resource availability and socio-economic attributes of farm households in the small transects of Nepal's mid-hill regions are due mainly to topographical differences, population density, market demand, and availability of infrastructure. The health implications of animal movements across

borders has always been a matter of concern of the CA and the importing countries involved. International transfers of any kind of animal represent a genuine risk for disease dissemination. Due to the rapid expansion of aquaculture in many countries, the trade in aquatic animals and their products has increased substantially (Blancou 1996). Large-scale international transfers of aquatic animals have been suggested as the source of introduction of exotic pathogens, which have causes enormous ecological and economical impact in the receptor country (Laurence, McDonald and Speare, 1996; Lightner, 1996). The trade in many species of live aquatic animals, freshwater and marine fish and shellfish for ornamental purposes can be as productive or more so than the trade in food fish. Millions of ornamental fish cross borders and continents every day, and as a consequence, concern has been raised, mainly in developed countries, that this trade risks spreading diseases wordwide. However, this concern is not reflected in the scientific literature. There is a large amount of information and quality research dedicated to food fish as disease vectors, whereas ornamental fish have been poorly studied. committed hobbyists have undertaken research (Ford, 1995).

Thusly, a study shows that poverty decreased considerably more in localities where salmon farms were installed than in localities without salmon farms. They identify the distances between localities and salmon farms where this impact was significant and the findings contribute to the debate on the socioeconomic effects of aquaculture for capital-intensive, international market-oriented industries (Adam., et.al, 2018). On the other hand, the pattern of participation and the determinants of participation in off-farm activities are heterogeneous across space. Some studies have been made to capture a farm location effect, the distance from big cities, and dummy regional variables. Regional characteristics of the off-farm labour market can potentially restrict individuals' access to off-farm work through high commuting costs and time (Corsi & Findeis, 2000; Lim-Applegate et al., 2002; Lopez; 1986). Such studies exposed the crucial behaviour on off-farm work activities suggested by farmer's mobility related with regional condition, such as to work to the nearest town or urban area. According to Lass et al. (1991), the supply of off-farm labour has been shown to be positively related to urban proximity. Moreover, Gardner (2001) found that the level of rurality of a place also seems to play an important factor that lead to join off farm employment. The more rural a location is, the less likely a farmer will engage in off-farm activities, mainly due to travel costs. Following this line of reasoning, we can also include distance to the nearest concentration of jobs and distance to the nearest city as related variables that probably have an impact on the share of farm activity. Studies showed that off farm employment location may affect the participation of farmers and their households due to the availability of a better transport system and related

infrastructures. Francisco and Peter (2001) claimed that the importance of off-farm agricultural activities or its rural dwellers as well as their distributional profile and poverty impact. Their study shows that returns to education are comparatively high and location in relation to urban areas is an important determinant of both employment and earnings in rural off-farm agricultural activities. Morgan (1991) found that the higher income levels of farm families located in and around the metro areas are the greater opportunities for off-farm employment. The location of nearest town, job availability, transportation system and public amenities also play a big role in the involvement of ornamental fish farmers in the study area. Chaplin et al. (2004) found that public transport in countries as Poland and Hungary has a positive effect on off-farm employment. However, a study done by Goodwin and Mishra (2004) about US farm families that the number of miles to the nearest town, a factor representing the cost of commuting, does not appear to significantly influence the supply of labour off the farm. Thusly, some studies found that spatial and location does not affect any off-farm job decisions. A study done using a spatial distribution and economic segmentation model showed that the type of employment opportunities in a county has a significant influence on the local poverty rate of a study area. Hence, geographical and spatial studies are not that crucial compared to economy, management, transportation, engineering, sciences and modelling compared to the other disciplines (Allen et al., 2012).

3. Methodology

Research on distribution of on and off-farm activities of ornamental fish farmers at Layang-layang was done through the survey. Layang-layang is presently has the highest number of ornamental fish exporter in Malaysia. Collected data was used to propose simplified statistics as an indicator of an area or a country. The limited usage of data will not be fully utilized and later, it will vanish and cannot be spatially referenced. Ornamental fish farmers at Layang-layang were assumed to have different preferences of which off-farm activities they would choose. Therefore, this study was conducted to determine the decision making of ornamental fish farmers in Layang-Layang towards a wide range of off-farm activities they like most to increase their income. However, their decision making whether to participate in off farm employment or not are affected by non-spatial structural characteristics including personal characteristics, fish farm characteristics and spatial characteristics. The relationship between off-farm work and a fish farm's economic performance indicates that a farm household's dependence on off-farm income affects the distributional consequences of agricultural policies in a country. In the terms of spatial analysis, spatial referencing data allows the data gathering on different geographical stages such as election area,

infrastructure services area, posting area or area that has postcode. Timing in a research is very important, as the GIS project timing may take some period with a high cost, about 80% from the project sources Ruslan (1996). Thus, GIS analysis and the usage need to be done earlier to make the data useable. In this study, the spatial data obtained were analysed and the distribution of data were displayed without creating a complicated database, as the database model for spatial data needs a specific data model where it can only be found in GIS, vector model and raster model.

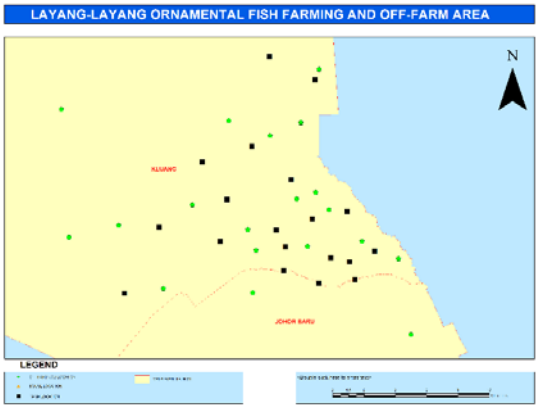

Figure 1. Layang-Layang Ornamental Fish Farming and Off-farm Area

3.1. Data Collection and Sampling Design

In this research the sample is the farmers households of ornamental fish farm of Layang-layang and the sampling characteristics of the population of interest are ornamental fish farmerswho engaged or not engaged in off-farm employment. Different analogue maps were provided by the Malaysian Department of Survey (JUPEM) and Department of Agriculture (DOA), which were used to prepare baseline GIS data for the study area. Such maps cover roads, rivers and streams, settlements, land use and the administrative boundaries. The study was targeted on ornamental fish farmers who participated or not participated in off-farm employment, the respondents are confined to Department of Fisheries. Census sampling method was used for selecting the representatives of farmers in Layang-layang. Structured questionnaire was used to interview the respondents;19 respondents were selected. A structured questionnaire was designed to know the recent status of off-farm employment among the farmers; the questionnaire consists of structured questions and was divided into two forms, dichotomous choice and multiple categories questions. The

dichotomous choice questions offer just two answer choices, yes or no. And the multiple categories questions have more than two answers choices.

3.2. Descriptive Analysis

This technique is used to describe the characteristics of the variables in terms of the frequencies and the percentage of distribution of the surveyed data. It also aids to make comparison among the variables. This analysis will include a summary derived from samples that will be used to illustrate the data graphically, which gives clear descriptions concerning the unvaried questions and the hypothesis of the variables. The descriptive analysis was used to describe the respondents' perception about off-farm employment and the factors that determine engaging in off- farm activities.

3.3. Spatial Analysis

Spatial analysis is a process of looking at geographical patterns in the data and the relationships between the features. Thus, the spatial analysis is also the process by which we could turn raw data into useful information. The method can be very simple or more complex, might involve models that mimic the real world by combining data layers as the analysis allows us to study the real–world processes including the present situation of specific areas and features, the change in situation or the trends as it includes all of the transformations, manipulations, and methods that can be applied to geographic data to add value to them, to support decisions, and to reveal patterns and anomalies that are not immediately obvious. In a more restricted sense, spatial analysis is the technique applied to structure the human scale, most notably in the analysis of geographic data. The demographic data are collected in spatial context and methods of analyses of spatial data include data description, map interpolation, exploratory data analyses (including descriptive statistics), explanatory analyses, and confirmatory data analyses (statistical inference, development and testing of models) (Haining, 1990). Spatial analysis functions ranged from simple database query to arithmetic and logical operation to complicated model analysis. The spatial analysis is a set of techniques for analysing spatial data. The results of spatial analysis are depending on the locations of the objects being analysed. ArcGIS is one of the GIS software that could implement spatial analysis techniques requires access to both the locations of objects and their attributes such as. Spatial analysis in the study was done based on a data set in which each observation is referenced to Layang-layang on respondents' house location, farm and off-farm activity's location.

4. Results and Discussion

The descriptive analysis was used to discuss the involvement of respondents in off-farm employment, distance to the nearest town and the relationship between them. Spatial analyses were done to get the geographic location between paddy farmer's house, on and off farm location including distance to the nearest town.

4.1 Descriptive Analysis Results

Table 1 below presents the off-farm employment participation of the respondents. In Layang-layang 52.6% of the respondents participated in off-farm employment, while 47.4% of the respondents did not participate in any kind of off-farm employment. From the result below, we can see that farmers in Layang-layang preferred to participate in off-farm employment.

Table 1. Participation in Off-farm Employment

Off-farm Participation in Layang-layang	n(19)	Percentage
Yes	10	52.6%
No	9	47.7%

Table 2 below presents the type of off-farm employment in which respondents participated. In Layang-layang 36.8% of the respondents participated in oil palm plantation; 10.5% involved in own job, involved in other type of agriculture and private company job represented 5.3% and 47.7% of the respondents did not participate in any kind of off-farm employment. From the analysis, we can see that total of 10 out of 19 respondents farmers in Layang-layang participated more in off-farm employment, especially related to agricultural activities including livestock rearing and other farming activities.

Table 2. Type of Off-farm Employment

Type of Off-farm Job	n(19)	Percentage
Aquaculture Only	9	47.4%
Agriculture – Oil Palm	7	36.8%
Own Job	2	10.5%
Agriculture and private company job represented	1	5.3%

4.2 Spatial Analysis Result

4.2.1 Distance from Home to Off-farm Type

Table 3 and Figure 2 below show the respondents' distance of home and the type of off-farm activity they engaged in. In Layang-layang, it can be seen that 47.7% of off-farm activities participants involved in agriculture, and 31.6% involved in non-agriculture with less than 10 kilometres distance away from their home. It can be observed from this study that, most respondents tend to do fisheries and agriculture job compared to non-agricultural job. Thus, location has a positive effect to the participation in off-farm employment, especially in agriculture activities; farmers who live near the off-farm location were seen involved in off-farm employment, because the farmer has more time to diversifying his source of income through agriculture activities.

Table 3. Distance of Home and The Type of Off-Farm Activity

Type of Off-farm Job	n(19)	Percentage	Off-farm Activity
Aquaculture Only	9	47.4%	No off-farm activity
Less than 10 km	6	31.6%	Oil Palm
11 to 20km	2	10.5%	Non Agriculture and private company job
21 to 30 km	1	5.25%	Agriculture
More than 31 km	1	5.25%	Own job

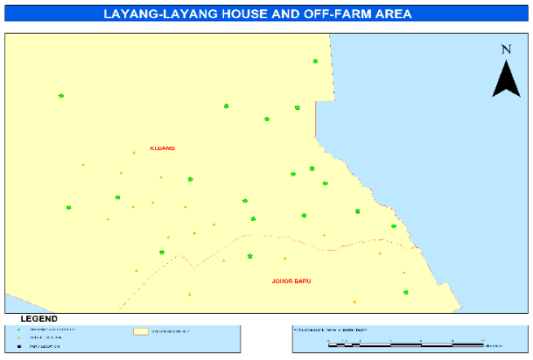

Figure 2. Layang- laying Distance from Home to Off-Farm

4.2.2. Distance from Home to Ornamental Fish Farm and Off-farm Type

Table 4 and Figure 3 below show the relationship between distance from home to ornamental fish farmand their types of off-farm activity. 36.8% of ornamental fish farmers who participated in agriculture as their off-farm activities were located less than 10 kilometres distance to their fish farm. 5.26% of ornamental fish farmers who participated in oil palm plantation as off-farm activities were located within 11 to 20 kilometres distance to their fish farms. 5.26% of ornamental fish farmers who participated in Non Agriculture and private company job as their off-farm activities were located more than 21 kilometres distance to their fish farms and home and 5.26% of ornamental fish farmers who participated in own job were located less more than 31 km from their fish farms and home. From this result, it can be concluded that house location has a positive effect to the participation in aquaculture and off-farm employment, especially in agriculture activities. Farmers who live near the ornamental fish farm will probably choose to do other agriculture activities because of their interests and the distance between locations do affect neither travelling time nor increase income.

Table 4. Distance from Home to Ornamental fish farm and Off-farm Type

Type of Off-farm Job	n(19)	Percentage	Off-farm Activity
Aquaculture Only	9	47.4%	No off-farm activity
Less than 10 km	7	36.8%	Oil Palm
11 to 20km	1	5.26%	Non Agriculture and private company job
21 to 30 km	1	5.26%	Agriculture
More than 31 km	1	5.26%	Own job

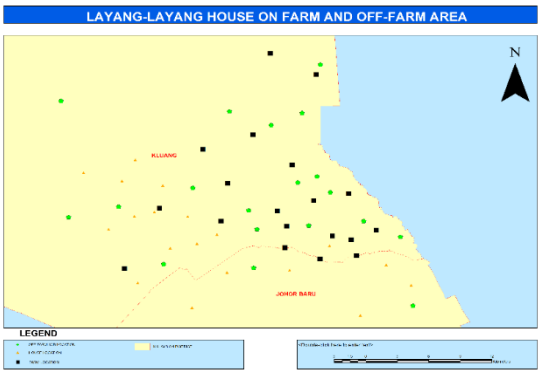

Figure 3. Distance from Home to Ornamental fish farm and Off-farm Job

4.2.3. Distance from Home to the Nearest Town and Off-farm Type

Table 5 and Figure 4 below show the relationship between distance from home to the nearest town and their type of off-farm job. In Layang-layang, it can be seen that 57.9% of ornamental fish farmers who participated in agriculture, Non Agriculture and private company job as their off-farm activities live less than 5 km distance to the nearest town and off –farm job. 36.4% who involved aquaculture lives 6 to 10 km from home and off –farm job and 5.3% who involved in aquaculture lived more than 11 km distance to the nearest town and off-farm job. From this result, it can be concluded that house location and nearest town have a positive effect to the participation in aquaculture and off-farm employment, especially in agriculture and fisheries activities; where they have more access to transportation linkage, suppliers and most probably close to public amenities.

Table 5. Distance from Home to the Nearest Town and Off-farm Type

Type of Off-farm Job	n(19)	Percentage	Off-farm Activity
Less than 5 km	6	31.6	Oil Palm
	3	15.8	No off-farm activity
	2	10.5	Non Agriculture and private company job
6 to 10 km	3	15.8	Oil Palm
	1	5.3	Non Agriculture and private company job
	1	5.3	No off-farm activity
	2	10.5	Agriculture
More than 11 km	1	5.3	Own job and Oil Palm

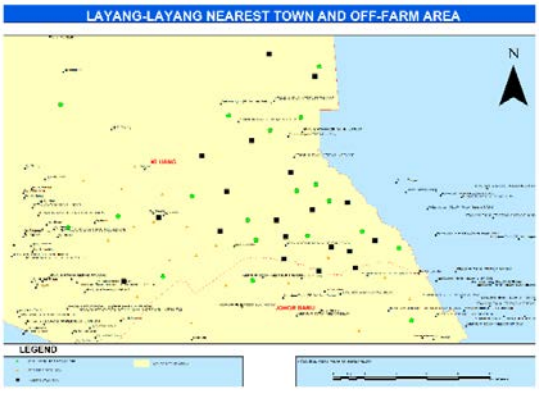

Figure 4. Distance from Home to the Nearest Town and Off-farm Type

5. Conclusions

Off-farm employment is an alternative strategy and has a potential to improve the income and wellbeing of the ornamental fish farmers in Malaysia. Besides, off-farm job helped to reduce income uncertainty in rural areas. The diversification of employment however helps to smooth income by spreading risk across several activities. In order to increase the participation of farmers in off-farm employment, policy should be formulated by the government to increase the availability of off-farm jobs in the vicinity of farmers' communities, since there may be great diversities in the social, cultural, economic and institutional characteristics among farmers' communities. Spatial analysis through GIS helps to determine the geographic patterns in the data and the relationships between the features. So the process of identification of on-farm and off-farm employment location and other spatial characteristics becomes easier.

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