Fish Farming and Off-Farm Activities in Sungai Siput, Perak using Geographic Information System (GIS) and Remote Sensing

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Abstract
Ornamental fish are fish that are kept in home aquariums or for recreational reasons. it's considered together of the fastest-growing in Malaysia's agriculture sector, especially within the export-oriented sub-sector. In 2015, a ban on the importation of certain Malaysian ornamental fish to the European Union (EU) was imposed.
Purpose: The study was designed to identify the location of fish farmers, using GIS and remote sensing supported by off-farm employment data from a sample population of 30 ornamental fish farmers in Sungai Siput, Perak.
Design/methodology/approach: The respondent's socio-economic profile is described using descriptive analysis. Cross-tabulated the link between farming involvement and the selected independent variables. The null hypothesis, however was tested using chi-square analysis. Farming operations were linked to spatial attributes in separate regions using a GIS and a Spot-6 images.
Findings: This study found that off-farm employment is a viable alternative method for improving the income and well-being of Malaysian ornamental fish producers. As a result, identifying on-farm and off-farm job locations, as well as other geographical characteristics, is simplified. Diversification of employment, on the other hand, aids in income smoothing by distributing risk across multiple occupations. A database of farm locations was built and spatial analysis was performed in order to monitor the farm by being spatially monitored from a web-based GIS system. The European Union (EU) imposed a goldfish and koi carp fish embargo in 2015, which had an impact on the entire business. In order to overcome the matter, the FBD developed the BioDOF-Map system which comprises the spatial and non-spatial data on the ornamental fish farmers. It is well-proven, with the help of BioDOF-Map system, there is so much more information that can be obtained and manipulated by the Malaysian government to

help improve the current policy and use it as an important input in strategic plans especially in the terms of aquaculture and agriculture.
Research limitations/implications: The study uses census method sampling. In the area, there were 30 farmers registered with FBD. There are numerous advantages to this, including easy access and inexpensive data collection expenses. Nonetheless, using purely aquaculture farmers sampling is also extremely limiting if the population of the study is comprised of people with various profiles.
Practical implications: After certain conditions are fulfilled, An instance is, when the study was conducted, the reliability of the data has been collected would have practical implications. It is suggested that the next study should cover non-aquaculture farmers in the area.
Originality/value: A web-based GIS system namely BioDOF-Map simplifies farms monitoring, which benefits the Department of Fisheries in the management of aquatic animal health has been developed in the year 2019.

Keywords: Ornamental Fish, Spatial Analysis, Fisheries Biosecurity, BioDOF-Map, Off-farm Employment

Introduction

Malaysia is known for its enormous freshwater fish breeding farms. Goldfish and koi carp farming has become limited due to limitations and fish health regulations, and many have specialised in Asian Arowana farming, which may or may not be of interest in the future. Aside from popular species like Livebearers, Barbs, Gourami, Tetras, and Cichlids, there is also extensive stingray, blood parrot, and Discus farming. Malaysia's contribution to the fisheries sector continues to play an essential role in the country's socioeconomic development. As a result, the sector has created jobs while also adding to the Gross Domestic Product (GDP) and foreign exchange. This industry has a lot of promise in terms of producing jobs and bringing in a lot of money for the government. Because the fisheries sector is important for national development, thorough resource management has been implemented to ensure the long-term viability of fisheries resources. The expansion of Malaysia's fisheries sector has benefited the country's economy as well as the inhabitants living near fishing resources. Progress in the fisheries sector has gradually had a favourable impact on the socio-economic development of the people who rely on this fishery source. The Fisheries Act of 1985 and all the Fisheries rules adopted thereunder are one of the greatest tactics for ensuring the seamless implementation of the Fisheries Department's in managing the department's fishery resources. DOF is known as the National Competent Authority (CA) responsible for all matters involving live fish in Malaysia.

According to the record, total marine fish landings were 1,486.1 thousand tonnes in 2016, up 1.9 percent from 1,458.1 thousand tonnes in the year 2014, while freshwater aquaculture production increased by 5.1 percent to 112.1 thousand tonnes in the year 2015. In addition, brackish water or saline aquaculture production declined by 4.7 percent to 394.3 thousand metric tonnes in 2016 compared to 2015. In the year 2016, the fishery sub-sector produced 2.06 million tonnes of fish, up 3.7 percent from 2015, and this production includes marine capture fisheries, land fisheries, and aquaculture. In terms of value, it increased by 9.24 percent from RM9.3 billion in 2015 to RM10.1 billion in the same time. In 2016, catchment and aquaculture fields produced 1.57 million tonnes of fish and 490,027 tonnes of fish, respectively, with aquaculture accounting for 407,403 million tonnes and RM2,784,721. The total value of the fisheries industry in 2017 was RM13 billion (Annual Fisheries Statistics, 2017). The 11th Malaysia Plan (11MP) is the Ministry of Agriculture and Agro-based Industry's five-year strategic goal for improving the agro-food industry through modernization, increased investment prospects, and improved marketing strategy. It may be argued that the ornamental fish culture industry contributes billions of dollars to the world economy on a yearly basis. On the other hand, the decorative fish market for public aquariums in the world is currently less than 1%, and over 99 percent of the ornamental fish business is restricted to hobbyist groups. Ornamental fish farming gave birth to the business concept, which is rapidly gaining popularity. However, we can observe that people, particularly from African and Asian countries, are increasingly entering the decorative business. Singapore, Hong Kong, Malaysia, Sri Lanka, Thailand, the Philippines, Taiwan, Indonesia, and India are the leading exporting countries. (Shabir Ahmad Dar et.al.,2018).

The Malaysian ornamental sector was doing well until the European Union (EU). issued a notice of non-compliance with a rule, standard, or practise. CAR was received based on the DG (SANTE) / 2015-7562 audit, which took place from March 09 to March 17, 2015, and was focused on monitoring the health management of aquaculture animals in aquaculture farms for export. The EU then imposed import restrictions. As a result, the breeders and the value of the country's exports have suffered as a result of this limitation. The Fisheries Bio-security Division of the California Department of Agriculture was in charge of maintaining and managing fish health and food safety, particularly for fish and fishery products. In order to avoid EU sanctions, FBD fulfils the function of fisheries bio-security in responding to an EU-issued audit using the Geographic Information System (GIS) as a tool. Bio-security is frequently characterised as procedures that reduce the number of infections that enter a facility, or "hazard reduction by environmental modification" (Plumb, 1992). Bio-security is the notion of preserving cultural animals against disease contamination and avoiding disease spread across borders, which has become increasingly critical as aquaculture production systems have become more intensive (Sachin O. Khairnar, et.al.,2018).

As a result, the purpose of this study is to investigate the regional characteristics of aquatic animal health management on 30 ornamental aquaculture farms in Sungai Siput, Perak. The study's structure will be accomplished by employing GIS and remote sensing to create a compartmentalization system. Malaysia will eventually be free of ornamental fish import restrictions at the end of this project, and this study will focus on farmers' farm and off-farm activities. The goal of this study is to identify the spatial characteristic variables in terms of aquatic animal health management on 30 ornamental aquaculture farms in Sungai Siput, Perak, by first creating demographic information on the farmers and then creating a compartmentalization system using GIS spatial analysis, with the hope that by the end of the project, Malaysia will be able to use the web-based GIS system as one of the tools and references for fish health monitoring.

According to Ruslan et al., (1998), identifying farmers, farms, and spatial factors of farming activities necessitates a high level of precision, as well as well-managed and up-to-date data from a variety of sources. This can be done with the use of a database that holds all of the study's relevant data. Using GIS and remote sensing, we will also be able to comprehensively enter, manage, alter, analyse, band display data related to geography or spatiality. Hence, Ruslan et al. (1998) found that both spatial and non-spatial data are vital in the GIS, according to the findings, and must be updated correctly to be useful to the user. Remote sensing, on the other hand, is the process of scanning the earth with a satellite or a high-flying aircraft in order to collect data about it. Remote sensing is the way of getting information without physically being present. The three most frequent remote sensing methods, for example, are an airplane, a satellite, and a drone. The art and science of measuring the earth with sensors on planes or satellites are known as remote sensing. The sensors' role is to collect data in the form of images, which are then edited, analysed, and displayed using specialist tools. Remote sensing imagery is included in a GIS.

Literature Review

Ornamental fish and the industry

The aquaculture industry is currently the world's fastest expanding food sector, and the open ocean is viewed as one of the most promising sites for large-scale expansion (Lovatelli, Aguilar-Manjarrez, & Soto, 2013; Rubino, 2008). The aquaculture sub-sector is made up of three main components: brackish-water aquaculture, freshwater aquaculture, and mariculture. Despite its long history, the aquaculture business did not start expanding and diversifying its products until the 1980s (Rabanal, 1995). Coastal brackish-water fish ponds dominated the country's principal aquacultural operations for a long time. Keeping ornamental fish is becoming increasingly popular as a simple and stress-relieving hobby. Ornamental fishes are colourful, appealing fishes with a variety of traits that are kept as pets in a confined place such as a garden pool for fun and an aquarium, for recreation. These living jewels don't always have to be brightly coloured; their unique traits, such as body colour, morphology, and, presumably, feeding mode, can all contribute to their appeal. For countries that deal with ornamental fish, more revenue is generated. On the other hand, while the ornamental fish market contributes a modest amount to global trade in terms of value, it is important in terms of poverty reduction in developing nations and marine preservation. In coastal and riverine communities, ornamental fish, which can be a sustainable and renewable resource, can be employed as a source of income to the community. As a result, the United States (US) and European countries are the world's major markets for ornamental fish. These fishes come in a wide variety of colours and breed in a variety of ways. Their activities and life spans differ depending on the species, and they can be found in brackish, salt, and fresh water. The ornamental fish industry is a tiny but important component of the global fish trade. It benefits rural development in many developing producing countries, and the retail value of ornamental fish is many times that of its trade value, resulting in a beneficial impact across the value chain. Tropical and subtropical developing countries provide the majority of ornamental fish. The overall value of ornamental fish and invertebrates imported into different countries throughout the world is estimated to be around $278 million USD (FAO 1996-2005). However, the majority of individuals in the trade are of freshwater origin and are generated in commercial aquaculture facilities, accounting for 90-96 percent of the total (Chapman 1997; Cato and Brown 2003). As a result, the international trade in ornamental fish provides employment opportunities for thousands of poor people in most developing countries. Every year, more species are added as a consequence of developments in breeding, transportation, and aquarium technology (V K Dey, 2016).

The Socio-economic and livelihood profile of ornamental fish farmers

Livelihood encompasses not only the activities that people engage in to make a living, but also the various factors that influence or contribute to their ability to make a living, such as the assets that allow them to gain access to human, natural, social, financial, and physical capital, as well as their use of this capital to meet basic needs (Messer and Townsley, 2003). The ornamental fish trade is increasing all over the world, and the ancillary industries linked with it, such as additional feed, pharmaceuticals, chemical production, and tank support services, create chances for breeders, farmers, aquarists, and others to make money (Itzkovich, 2011). As a result, it's vital to understand how those who work in this industry make a living. The ornamental fish trade is a multibillion-dollar sector that spans over a hundred nations throughout the world, including Africa, South America, and Southeast Asia, where it is a key source of wealth. However, some research groups have shifted their focus from food to ornamental fish in their aquaculture study. The rearing, breeding, and sale of ornamental fish is a substantial industry that generates jobs and foreign exchange for the country. However, there are worries about the industry's economic viability and environmental sustainability.

Ayyappan and Krishnan (2004) discovered in their study that the fishing sector provides a significant portion of the economically disadvantaged people with a source of income. In some locations, such as South America, the sale of these fish is often a family's only source of income (Chao, 1995a). In the year 2016, Malaysia has around 259 ornamental fish exporters (Department of Fisheries, 2016). As a result, it is estimated that over 1.5 million people work in this industry, with over 3.5 million enthusiasts around the world (Dey, 2010).
Ornamental fisheries are rapidly gaining traction as a profitable horizontally integrated commercial aquaculture endeavour. Though ornamental fish keeping began as a hobby around the world, it has evolved into a commercially traded commodity in several regions of the world due to increased demand in national and international markets (Ukaonu et al. 2011). Indeed, according to Stallard (1994), the Department of Ichthyology and Fisheries Sciences at Rhodes University in the Republic of South Africa had previously focused on the culture of food fish, but has now moved its focus to ornamental fish because they believe that "it was better to create jobs in paying businesses so that people can buy food, rather than to try and develop 'cheap' protein sources and never elevating people's to the level of comfort in which people live." The ornamental fish industry has been acknowledged for its ability to create jobs and contribute to national income growth by increasing foreign exchange profits. With the amazing rise in demand for ornamental fishes around the world, more countries have recognised the sector's economic potential and are actively promoting its expansion (Lee, 2005). And, as prohibitions on gathering animals from the wild are imposed, production of animals for the ornamental fishes trade is a rapidly developing segment of the aquaculture industry that will continue to increase in importance (Tlusty, 2001). According to study, ornamental fish culture has generated a paradigm shift among entrepreneurs, ushering in economic development. Gurumayum and Goswami (2002) concluded that ornamental fish culture has caused a paradigm changes among entrepreneurs, helping in economic development. The global ornamental fish market has been steadily expanding over the years, and an increasing number of businesses are taking an interest in the industry.

Fisheries Biosecurity Division (FBD)

Bio-security is a set of strategies and processes for keeping pathogenic organisms and disease from entering, emerging, spreading, and persisting in and around fish production and holding facilities. In general, it is a planned and integrated strategy to identify and control relevant hazards to fish health as well as associated environmental issues. These procedures are applicable at all levels of the ornamental fish industry, including producers, wholesalers, retailers, and hobbyists, and help avoid factors that can increase disease susceptibility among fish. DOF joined the World Trade Organization (WTO) in 1995 and ratified the Sanitary and Phytosanitary (SPS) Agreement, which was created to protect human, animal, and plant life and health in the nations. Because the FBD was mandated explicitly, it must ensure that fish diseases are limited and that fish and fisheries products are free of contaminants so that they can be consumed safely by humans. In order to achieve these aims, FBD performs measures such as official control, official analysis, and official assurance at the primary production level of the supply chain, such as aquaculture farms, feed mills, and fishing vessels, including the fish meal manufacturing plants.

Geographic Information System (GIS) and Remote Sensing

GIS is defined as the integration of computer and software with spatially referred digital data for the purposes of retrieving, storing, analyzing, manipulating, and displaying all types of geographically linked data. GIS also stands for Geographic Information System, and it is a computer-assisted system that can input, save, retrieve, analyse, and display spatially referenced data for management decision-making. As a result, GIS is a set of tools for analysing spatial data. Burrough (1986) characterised GIS as one of the most powerful data sets for gathering, storing, altering, and displaying real data in a spatial context. According to Clarke (1995) defined GIS as a computer system used for the purposes of gathering, storing, analyzing, regaining, and presenting spatial data. The use of geographic information systems (GIS) in social science is currently limited, although it has enormous potential, particularly in fisheries monitoring. As a result, GIS can be defined as a tool designed to handle specific problems. Thus, doing demographic research with GIS refers to two different phenomena in the same geographical spatial location, including humans and other types of phenomena such as a farm, road, house, river, or forest that stays evenly in geographic spatial. Individual person information will be combined with another spatial object, such as a house address or a small unit of survey data. It differs from tangible items such as highways in that it is difficult to foresee an individual's reallocation as the complete and reliable database is the most important component in GIS where GIS covers the data model attribute and spatial data. According to Clarke (1997), the GIS can connect the attribute data model with the spatial data model, which can then be combined with the sharing ID. The capacity to evaluate and visualize the agricultural environment and workflows using a GIS has proven to be extremely beneficial to world especially to the farming industry.

Remote sensing, on the other hand, is a technique for detecting and monitoring an area's physical characteristics from afar by measuring reflected and emitted radiation. Remotely sensed photographs of the Earth are known to be captured by special cameras, which enable researchers in monitoring and sensing items on the globe. Remote sensing, as contrast to on-site observation, is defined as the acquisition of information about an object or phenomenon without establishing direct contact with the object. Remote sensing is utilised in a variety of sectors, including geography, land surveying, and most Earth Science disciplines, such as hydrology, ecology, oceanography, and geology; it also has intelligence, military, economic, commercial, and planning uses. It refers to the employment of satellite- or aircraft-based sensor technology to identify and classify things on Earth based on propagated signals, including those on the surface, in the atmosphere, and in the oceans. As a ground monitoring referral source, the study uses a SPOT-6 satellite picture. On September 9, 2012, a PSLV launcher from India's Satish Dhawan Space Center successfully launched the SPOT-6 satellite sensor developed by AIRBUS Defence and Space. The SPOT-6 satellite is an optical imaging satellite that can take pictures of the Earth. Customers in the defence, agriculture, deforestation, environmental monitoring, coastal surveillance, engineering, oil, gas, and mining industries will benefit from the SPOT-6's 1.5 metre panchromatic and 6 metre multispectral (blue, green, red, near-IR) resolution. Plus, with SPOT 6 and SPOT 7, Astrium ensures the SPOT series' mission continuity, having collected more than 30 million scenes since 1986. Whilst, the SPOT-6 is an optical satellite with technological advancements and increased system performance that improves reactivity and acquisition capacity while also making data access easier to the user.

Spatial Distribution and Distance Characteristics

The study's purpose was to create a basic database that would aid in the identification of ornamental fish farm spread using GIS and statistical analysis with SPSS software. As a result, GIS is a technology sector that maps, analyses, and evaluates real-world situations by combining geographic components with tabular data. The actual power of GIS comes from its ability to evaluate attribute and geographic data using spatial and statistical methodologies. The analysis can produce derived gained information, interpolated information, or prioritized information as a result (Amod Ashok Salgaonkar, et.al., 2018). Tabular data, also known as attribute data, is frequently associated with this data. Additional information about each of the spatial elements in the database is referred to as attribute data. An example of this would be the location of a farm. The attribute data would include information such as the farmer's name and level of schooling. Leeuwen et al. (2008) discovered the relevance of off-farm activities in different regions of the Netherlands, as well as their potential implications on agricultural policy efficiency. The findings show that the location of farm families along the spatial gradient affects farmers' livelihoods and resource availability. Starr and Estes (1990) discovered that a computerised information system, such as a Geographic Information System (GIS), which provides tools for the display and analysis of spatial data, is best suited to handle location-specific information from an ornamental fish farm for the entire country.

It stores geographic data, retrieves and combines it to create a new representation of geographic space, offers geographic analysis tools, and runs simulations to help experts in a range of industries, including the transportation and agricultural development (Rigaux et al., 2002). The GIS visualises and analyses socioeconomic data, which could help many social scientists better grasp how geographical situations affect socioeconomic reality. Bhatta and Doppler (2010) found that changes in resource availability and socio-economic features of farm households in small transects of Nepal's mid-hill areas are mostly related to topographical variances, market demand, population density, and infrastructure availability. The usage of GIS in the study is crucial because it is utilized to monitor the farm. The CA and the importing countries have always been concerned about the health effects of animal movements across borders. Transfers of any sort of animal across international borders pose a real risk of disease transmission. The trade-in aquatic animals and their products has increased significantly as a result of the fast spread of aquaculture in many nations (Blancou 1996). Exotic infections have been introduced into the receptor country via large-scale international transfers of aquatic animals, which have had tremendous ecological and economic consequences (Laurence, McDonald and Speare, 1996; Lightner, 1996).

Plus, the trade-in of freshwater and marine fish, numerous aquatic creatures, and shellfish for decorative purposes can be as prolific as or more productive than the trade-in of food fish. Every day, millions of ornamental fish cross borders and continents, causing concern, mostly in affluent countries, that this trade risks spreading diseases over the world. However, the scientific literature does not reflect this worry. Food fish as disease vectors have received a lot of attention and high-quality research, whereas ornamental fish have received little attention. Dedicated amateurs have conducted research (Ford, 1995). As a result, the study discovered that poverty decreased substantially more in places where salmon farms were built than in areas where they were not. They highlight the distances between localities and salmon farms where this influence was significant, and their findings add to the conversation on aquaculture's socioeconomic impacts for capital-intensive, global market-oriented businesses (Adam., et.al, 2018).

However, such research uncovered the critical behaviour on-farm labour activities suggested by farmers' mobility related to regional conditions, including working in the neighbouring town or metropolitan area. Because of the high cost of travel, farmers in more remote areas are less likely to engage in off-farm activities. Following this logic, we can add distance to the nearest job concentration and distance to the nearest city or town to the list of linked variables that are likely to influence the percentage of farm activity. According to studies, the availability of a better transportation system and related infrastructures may affect the engagement of farmers and their family in farm employment locations. Ornamental fish farmers' participation is influenced by the research area's proximity to the next town, job availability, transit system, and public facilities. Their findings show that educational returns are relatively high, and that location in relation to metropolitan centres is a crucial factor in rural off-farm agriculture firms' employment and incomes. The number of miles to the next town, a measure assessing the cost of commuting, did not appear to have a significant impact on the supply of labour outside the farm in a research by Goodwin and Mishra (2004) of US farm families.

Method

A survey and field verification was used to investigate the distribution of ornamental fish producers in Sungai Siput, Perak. Statistically, Perak's Sungai Siput now has the biggest number of ornamental fish exporters in Malaysia. Farmers of ornamental fish in Sungai Siput, Perak, were thought to have different preferences for agricultural activities. As a result, this study was carried out to identify how ornamental fish farmers in Sungai Siput, Perak make decisions about a wide range of farm activities that affect the country's ornamental fish export trade value. Non-spatial structural elements such as personal traits, fish farm features, and geographical characteristics, however, influence their decision to join. The relatioship between farm work and the economic performance of a fish farm suggests that a farm household's reliance on farm revenue has an impact on the distributional effects of agricultural policy in a country studied.

In the terms of spatial analysis, Ruslan (1996) claimed that using spatial referencing data, data can be collected on numerous geographical phases, such as election areas and infrastructure services areas. Research timeline is critical, as GIS project duration can take a long time and cost a lot of money (about 80% from project sources). As a result, GIS analysis must be completed earlier in order for the data to be trustworthy and usable. In this work, the obtained spatial data were assessed. Later, the data distribution was visualised by creating a simple database, because spatial data database models require a unique data model that can only be found in GIS, vector model, and raster model. The remote sensing data will be used to determine the farm location. Later, researchers can use remote sensing to track and monitor risk areas over time, determine desertification factors, assist decision-makers in defining applicable environmental management policies, and analyze their effects (Begni G.et. al 2005).

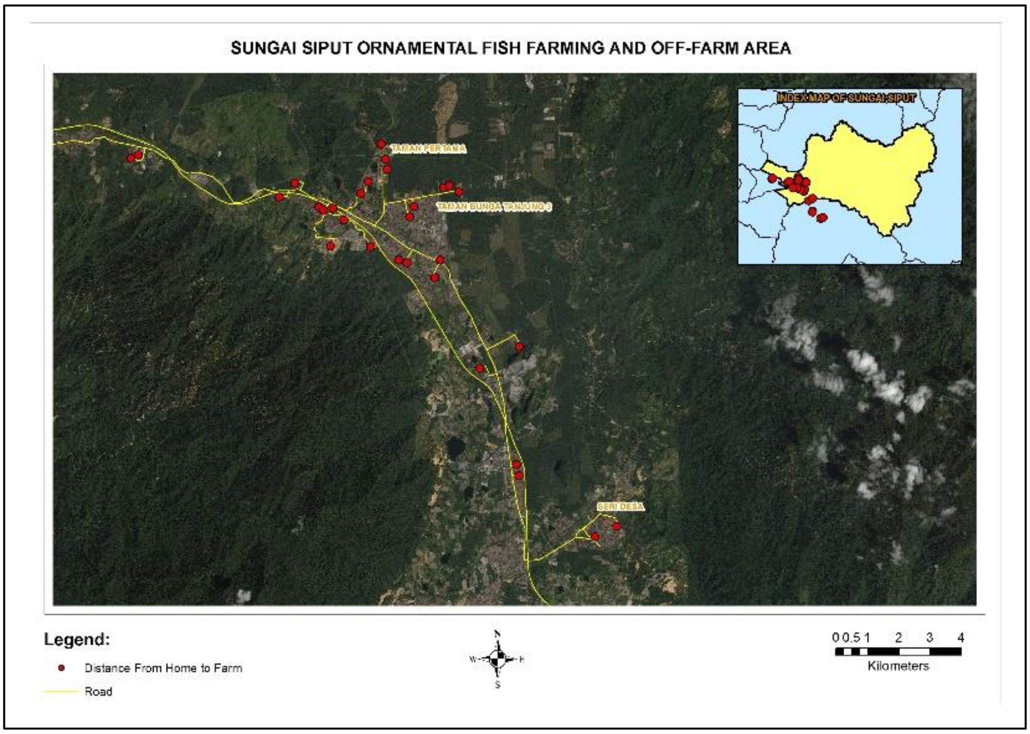

Figure 1: Sungai Siput, Perak Ornamental Fish Farming Area

Data Collection and Sampling Design

The study's participants were ornamental fish producers in Sungai Siput, Perak. The respondents are restricted to the Department of Fisheries, and the representatives of farmers in Sungai Siput, Perak, were chosen using the census sample method. For the primary method, a systematic questionnaire was designed and used to interview the respondents; 30 people were chosen. To learn more about the current condition of off-farm employment among ornamental fish farmers, a structured questionnaire was devised. The questionnaire, on the other hand, consists of structured questions divided into two categories: multiple category questions and dichotomous choice questions. There are only two options for dichotomous choice questions: yes or no. In addition, the questions with numerous categories contain more than two answer options. The Department of Agriculture (DOA) and the Malaysian Department of Survey (JUPEM) produced analogue maps for the secondary approach. And, finally the spatial data were used to prepare the baseline GIS data for the study area including digital maps that cover the administrative boundaries, land use, settlements, roads, rivers and streams.

Descriptive Analysis

Descriptive analysis was used to characterise the properties of the variables in terms of the percentage of distribution and frequencies of the surveyed data, and descriptive analysis was used to characterize the respondents' perceptions and associated data of the study. In preparation for future statistical analysis, the descriptive analysis provides an overview of the data distribution, aids in the detection of outliers and errors, and allows for the identification of links between variables.

Chi-Square Analysis

One technique to illustrate a relationship between two category variables is to use chi-square analysis. Numerical (countable) variables and non-numerical (categorical) variables are the two types of variables in statistics. As a result, the chi-squared analysis is a single value that informs you how much difference there is between your observed counts and the counts that would be expected if the population had no association at all. The formula is:

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

The degrees of freedom are denoted by the subscript "c." The actual value is "O," while the predicted value is "E." It's uncommon that you'll wish to utilise this formula to manually calculate a critical chi-square number. Furthermore, the summation sign indicates that you must conduct a calculation for each and every data item in your data set.

Spatial Analysis

Spatial analysis, often known as locational analysis, is a sort of geographical analysis that aims to present patterns of human behavior and their spatial expression in terms of geometry and mathematics. Because aquaculture is expected to continue to expand, intensify, and boost production for the foreseeable future, understanding the spatial challenges associated with aquaculture is crucial (FAO, 2018). Spatial tools are required for organising and reporting data so that it can be viewed from a single point of view or from several points of view (G. Yucel-Gier et al., 2010). GIS creates geographical data through spatial analysis, and the resulting information is more informative than unorganized data. With the help of statistics and geographic information systems, spatial analysis can be done in a variety of ways (GIS). A GIS

permits attribute interaction with geographic data in order to improve spatial analysis interpretation accuracy and prediction (Gupta, 2005).
Burrough (2001) discovered that an appropriate geospatial technique is chosen to be implemented with GIS based on the end- user's requirements. GIS can supply an infinite quantity of information in research because it incorporates technology, software, and data for acquiring, maintaining, analysing, and displaying all types of spatially related information (Foote and Lynch, 2015). The classification and manner of analysis will be determined by the geospatial approach chosen. The purposes of geographic analysis varied from simple database queries through arithmetic and logical operations to complex model analysis, which is a collection of methodologies for analysing spatial data. The position of the things being investigated affects the outcomes of spatial analysis. ArcGIS software was used for all GIS work in the study. ArcGIS is a geographic information system (GIS) programme that may be used to implement spatial analytic techniques that require access to both object locations and attribute properties. The benefit of combining satellite remote sensing with geographic information systems (GIS) is that it enables for a more full and integrated assessment of fish pond development requirements, which is difficult to achieve using traditional methods alone (Ogunlade S., 2020). The spatial analysis of the study was based on a data set in which each observation on respondents' home, farm, off-farm activities, and dwelling location was referenced to Sungai Siput, Perak.

Findings
The descriptive analysis was used to evaluate the respondents' involvement in farm operations, as well as their distance from the nearest town and their relationship. In this study, the Chi-Square analysis was employed to investigate the association between two categorical variables. As a result, spatial analyses were carried out to determine the geographic location between the farmer's house and the farm, as well as the distance to the next town.

Descriptive Analysis Results
The age of the respondents is shown in Table 1 below. In Sungai Siput, Perak, 40.0 percent of those over 40 years old, 30.3 percent of those 31 to 40 years old, 20.0 percent of those 21 to 30 years old, and 6.7 percent of those under 20 years old participated in agriculture activities. Farmers in Sungai Siput, Perak, who participated in farm activities include senior farmers who view aquaculture operations to be their main source of income and do not intend to stop farming activities, according to the results below.

Table 1: Participation in Off-farm Employment

Age of Farmers	***n(30)***	***Percentage (%)***
< 20 years old	2	6.7
21 to 30 years old	6	20.0
31 to 40 years old	10	30.3
> 40 years old	12	40.0

Table 2 below presents the type of fish being reared in which respondents participated. In Sungai Siput, Perak 50.0% of the respondents reared Cyprinids Barb/Danio/Goldfish/Koi, 43.3% reared Poecilids and 6.7% reared Anabantids. From the analysis, we can see that total 15 respondents farmers in Sungai Siput, Perak reared Cyprinids Barb/Danio/Goldfish/Koi because of the market demand over the fish type locally and abroad.

Table 2: Type of Fish Reared

Type of Fish Reared	*n(30)*	*Percentage (%)*
Cyprinids Barb/Danio/Goldfish/Koi	15	50.0
Poecilids	13	43.3
Anabantids	2	6.7

Chi-Square Analysis Result

Age and Off-farm Chi-Square

Table 3 shows that 17 of the 30 respondents were above the age of 40, 7 were between the ages of 31 and 40, 4 were between the ages of 21 and 30, and 2 were under the age of 20. We can observe from this hypothetical table that the hypothesised association between age and aquaculture farmers' participation in off-farm jobs does exist. Farmers' age had no statistically significant relationship with their participation in off-farm employment, with a chi-square value of 0.000, a level of significance of 0.000, and a degree of freedom of 3 where there was no age limit for off-farm employment. As a result, the null hypothesis is rejected.

Education and Off-farm Chi-Square

We can see from the hypothetical Table 3 that the hypothesised association exists and that the frequency patterns differ from random expectations. As can be seen from the table, there is a clear link between education and farmers' participation in off-farm jobs. With a chi-square value of 36.916 with 7 degrees of freedom and 0.000 level of significance, education has a statistically significant relationship with their participation in off-farm employment, with the highest proportion among SPM holders and the lowest in those with a Degree. As a result, the null hypothesis must be rejected.

Income and Off-farm Chi-Square

We can see from the hypothetical Table 3 that the hypothesized association exists and that the frequency patterns differ from random expectations. As seen in the table, there is a definite link between aquaculture farmers' income and their engagement in off-farm jobs. With a 0.000 level of significance, income has a statistically significant relationship with their engagement in off-farm employment. As a result, the null hypothesis must be rejected.

Table 3: Chi-Square Analysis

Variables	*Chi-Square ($X^2_{0.05}$)*	*Df*	*Significance*	*Decision*
Age	32.508[a]	3	0.000	Reject H_O
Education	36.816[a]	7	0.000	Reject H_O
Income	124.121[a]	5	0.000	Reject H_O

Spatial Analysis Result

Distance of Home and The Farm Location

The distance between respondents' homes and their farms is shown in Table 4 and Figure 2 below. In the Perak town of Sungai Siput, 50.0 percent of ornamental fish growers live within a 10-kilometer radius of their homes. According to the findings of this study, the majority of respondents choose to work in agriculture near their homes. As a result, the farmer's location has an impact on off-farm activity since he has more time to diversify his source of income through agriculture activities.

Table 4: Distance of Home and The Farm Location

Distance Between Home To Farm Location	***n(30)***	***Percentage (%)***
< 10 km	15	50.0
11 to 20 km	12	40.0
21 to 30 km	3	10.0
> 31 km	0	0

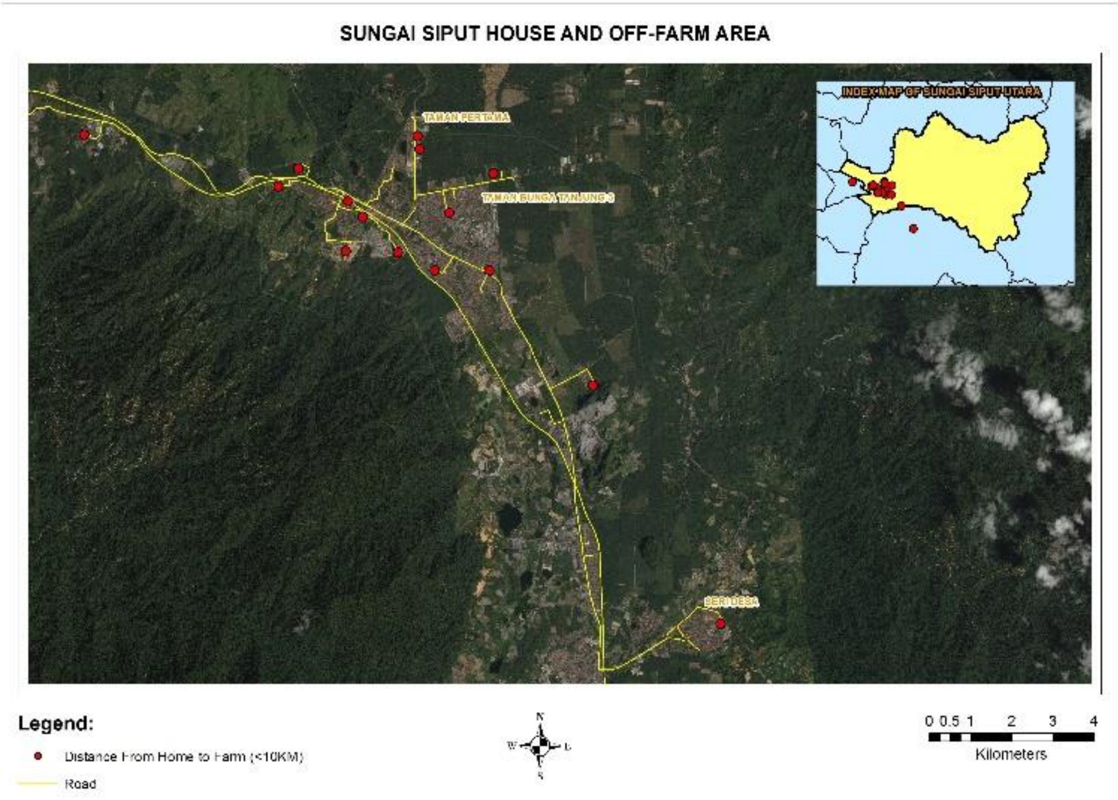

Figure 2: Sungai Siput, Perak's Distance of Home and The Farm Location

Distance from Home to Ornamental Fish Type

Table 5 and Figure 3 below show the relationship between distance from home to ornamental fish type in Sungai Siput,Perak. 50.0% of ornamental fish farmers who participated in Cyprinids Barb/Danio/Goldfish/Koi, Poecilids and Anabantids farming were located less than 10 kilometers distance to their house. 43.3% of ornamental fish farmers who participated in rearing Cyprinids Barb/Danio/Goldfish/Koi and Poecilids lives 11 to 20 kilometers distance to their house and 6.7% of the respondents who reared in Cyprinids Barb/Danio/Goldfish/Koi and Anabantids lived 21 to 30 km away from their house. From this result, it can be concluded that house location has contributed to the participation in the rearing of Cyprinids Barb/Danio/Goldfish/Koi, Poecilids, and Anabantids in aquaculture. Farmers who reside near an ornamental fish farm are more likely to engage in farming activities because of their interests, and the distance between locations has an impact on both trip time and cost savings.

Table 5: Distance from Home to Ornamental Fish Type

Distance	***n(30)***	***Percentage (%)***	***Fish Type***
Less than 10 km	15	50.0	Cyprinids Barb/Danio/Goldfish/Koi, Poecilids and Anabantids
11 to 20 km	13	43.3	Cyprinids Barb/Danio/Goldfish/Koi, Poecilids
21 to 30 km	2	6.7	Cyprinids Barb/Danio/Goldfish/Koi, Anabantids
More than 31 km	0	0	

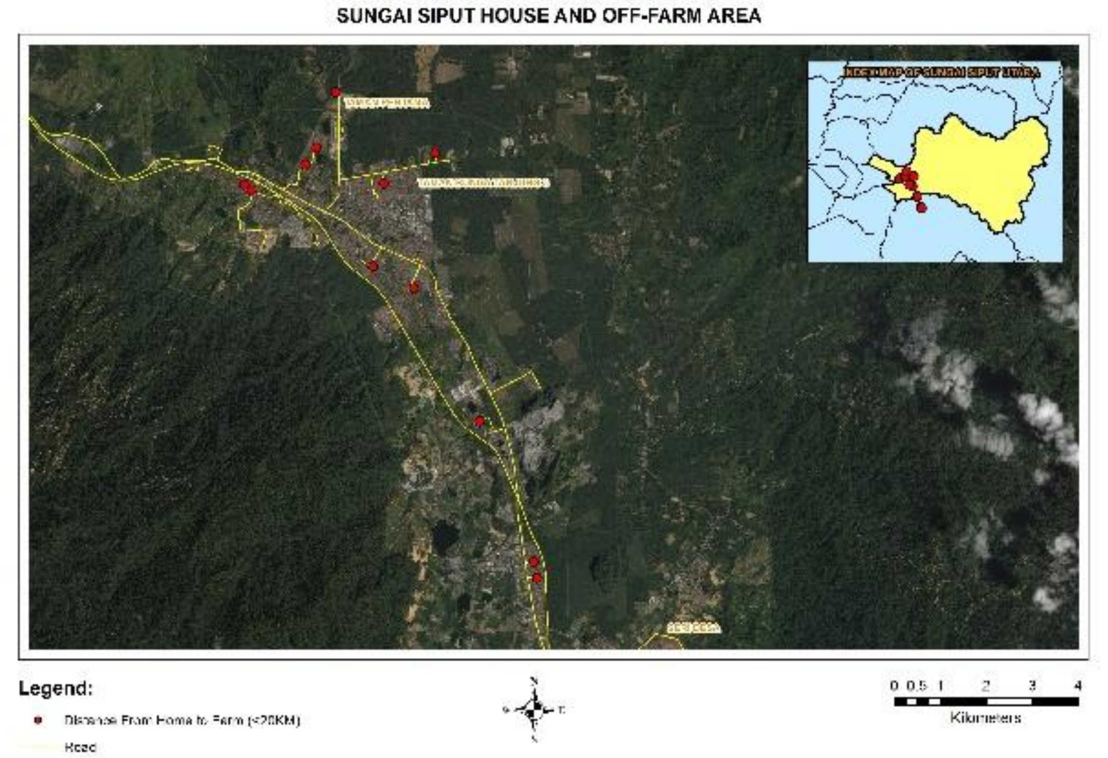

Figure 3: Distance from Home to Ornamental Fish Type

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

Table 6 and Figure 4 below show the relationship between distance from home to the nearest town and their type of fish reared in Sungai Siput, Perak. It can be seen that 26.3% of ornamental fish farmers participated in rearing Cyprinids Barb/Danio/Goldfish/Koi, Poecilids and Anabantids live less than 5 km distance to the nearest town and off-farm employment. 21.1% who reared Cyprinids Barb/Danio/Goldfish/Koi, Poecilids and Anabantids live 6 to 10 km from home and off-farm job and 15.8% of the farmers who involved lived more than 11 km distance to the nearest town and reared Cyprinids Barb/Danio/Goldfish/Koi and Poecilids fish type. As a result of this finding, it can be concluded that the location of one's home and the proximity of a town have an impact on one's decision to participate in aquaculture and the type of fish raised, as they have easier access to suppliers, transportation, and are most likely close to public amenities.

Table 6: Distance from Home to the Nearest Town and Fish Type

Distance	***n(30)***	***Percentage (%)***	***Fish Type***
Less than 5 km	5	26.3	Cyprinids Barb/Danio/Goldfish/Koi, Poecilids and Anabantids
	4	21.1	Cyprinids Barb/Danio/Goldfish/Koi, Poecilids and Anabantids
	3	15.8	Cyprinids Barb/Danio/Goldfish/Koi, Poecilids
6 to 10 km	2	10.5	Cyprinids Barb/Danio/Goldfish/Koi, Poecilids and Anabantids
	1	5.3	Tiger Barb
	2	10.5	Cyprinids Barb/Danio/Goldfish/Koi
	1	5.3	Cyprinids Barb/Danio/Goldfish/Koi
More than 11 km	1	5.3	Cyprinids Barb/Danio/Goldfish/Koi, Poecilids

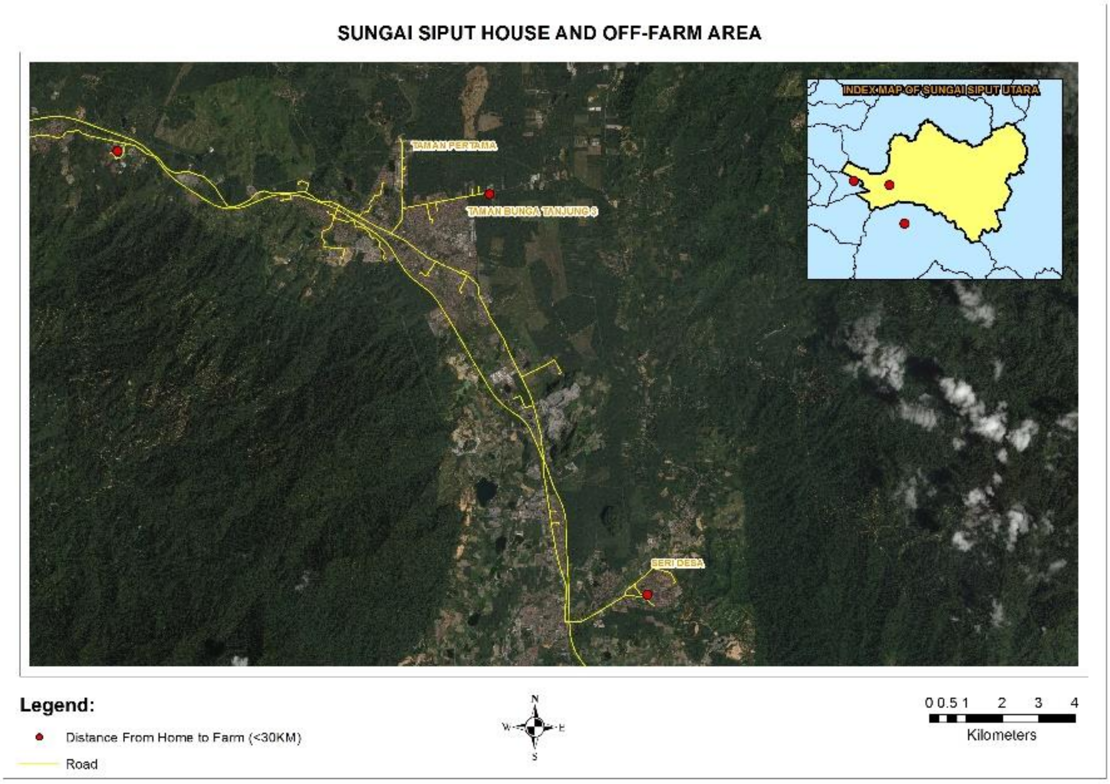

Figure 4: Distance from Home to the Nearest Town and Off-farm Type

Discussion and Conclusion

This study found that off-farm employment is a viable option for improving the income and well-being of Malaysian ornamental fish producers. As a result, identifying on-farm and off-farm job locations, as well as other geographical characteristics, becomes simpler. Diversification of employment, on the other hand, helps to smooth income by distributing risk across multiple activities. A database of farm locations was constructed, and spatial analysis was performed, in order to monitor the farm by being spatially watched from a system. The European Union (EU) imposed a goldfish and koi carp fish embargo in 2015, which has had an impact on the broader sector. To address the issue, the FBD created the BioDOF-Map system, which combines spatial and non-spatial data. The embargo of goldfish and koi carp fish by the European Union (EU) in 2015 do affect the overall industry. In order to overcome the matter, the FBD developed the BioDOF-Map system which comprises the spatial and non-spatial data on the ornamental fish farmers. It is well-proven, with the help of BioDOF-Map system, there is so much more information that can be obtained and manipulated by the Malaysian government to help improve the current policy and use it as an important input in strategic plans especially in the terms of aquaculture and agriculture.

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