RES MILITARIS
REVUE EUROPEENNE D ETUDES EUROPEAN JOURNAL OF MILITARY STUDIES
Social Science Journal

GIS Application: Ornamental Fish Farming and Off-Farm Employment in Perak

By

Eleanor Daniella Binti Lokman
Department of Agribusiness and Bioresource Economics, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 UPM, Serdang, Selangor
Email: eleanor@dof.gov.my

Norsida Binti Man
Department of Agribusiness and Bioresource Economics, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 UPM, Serdang, Selangor
Email: norsida@upm.edu.my

Abstract

Background

Recent agricultural innovations have cast question on the sustainability of current production techniques, which have felt the brunt of the coronavirus pandemic's devastating impact on the country's economy and agriculture. A lack of available labour and other inputs, as well as falling output prices due to falling commodity demand in some markets, have all disrupted production in the sector. To better the economic situation of the farmers who have registered with the fisheries biosecurity division, off-farm employment is referred to as a significant approach for supplementing farm household income and maintaining rural livelihoods. For rural communities and families, making a living from the land is as important as farming.

Objective

The goal of this project is to use GIS to create a map of all 30 of Perak's ornamental aquaculture farms, off-farm employment, house and town location.

Methods

The study used a survey and a geographic information system (GIS) to identify the impact of farm location on farm operational activities, particularly those pertaining to fisheries bio-security.

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

Introduction

One of Malaysia's most well-known exports is the freshwater fish produced in its vast freshwater farms. As goldfish and koi carp cultivation have become constrained by legislation and fish health rules, farmers have specialised in Asian Arowana farming, which may or may not be of future importance. Many individuals keep stingrays, blood parrots, and Discus in their aquariums in addition to the more common Livebearers, Barbs, Gourami, Tetras, and Cichlids. Malaysia's economy has traditionally relied heavily on the fishing industry. GDP, foreign exchange, and employment have all improved as a result of this sector. There is scope in this area for the creation of both private sector jobs and public sector tax revenue.

The fisheries industry is vital to national growth, hence it's been heavily regulated for resource management purposes. Economic growth and higher living standards in coastal areas have resulted from the development of Malaysia's fishing industry. As a result of advancements in the industry, villages heavily reliant on fishing have seen their economies flourish. One of the best ways to ensure that the Fisheries Department's management of fisheries resources is carried out without a hitch is to adhere to the Fisheries Act of 1985 and the Fisheries rules enacted thereunder. The Department of Fisheries (DOF) is Malaysia's highest authority on matters relating to fish in captivity.

Freshwater aquaculture production increased by 5.1% to 112.1 metric tonnes in 2015, while marine fish landings increased by 1.9% to 1,486.1 metric tonnes in 2016 from 1,458.1 metric tonnes in 2014. Aquaculture in salt water or brackish water saw a 4.7% drop in output in 2016, with a total of 394.3 kilo tonnes. In 2016, 2.06 million tonnes of fish were harvested worldwide, an increase of 3.7% from the year before. This figure includes fish harvested from both marine capture fisheries and land fisheries, as well as fish produced in aquaculture. This is a 9.24 percent growth from 2015, when the value was RM9.3 billion, to 2016, when it was RM10.1 billion. In 2016, catchment areas provided 1.57 million tonnes of fish and 490,027 tonnes of fish, while aquaculture lands provided 407,403 million tonnes and RM2,784,721. Overall, 2017 saw RM13 billion in revenue from the fishing industry (Annual Fisheries Statistics, 2017). The expected catch of marine fish in Malaysian waters fell by 1% from 2017 to 2018, to 1.45 million mt.

The 11th Malaysia Plan (11MP) is a 5-year strategy devised by the Malaysian government's Ministry of Agriculture and Food Industry to modernise the agro-food sector through expanded investment opportunities, improved marketing, and expanded distribution. It has been said that the cultivation of ornamental fish contributes billions of dollars annually to the global economy. Over ninety-five percent of the ornamental fish business is driven by the hobbyist market, whereas less than one percent is driven by public aquariums.

The rising popularity of ornamental fish breeding has sparked the development of novel approaches to the market. The ornamental business, however, is seeing a rise in new entrants, particularly from Asia and Africa. There are several important exporters in Asia. Some of these countries are Singapore, Hong Kong, Malaysia, Sri Lanka, Thailand, the Philippines, Taiwan, Indonesia, and India (Shabir Ahmad Dar et al.,2018).

The ornamental industry in Malaysia was thriving up to the time an EU notice of non-compliance with a regulation, standard, or practise was issued. The DG (SANTE) / 2015-7562 audit, which took place from March 9-17, 2015, aimed to keep an eye on how well aquaculture farms were keeping their animals healthy before sending them off to new markets. This CAR represents the result of that audit. As a result, the EU placed restrictions on imports. This restriction has been detrimental to both breeders and the country's export value. The California Department of Agriculture had a division dedicated to ensuring the safety of fish for human consumption, and that division was the Fisheries Biosecurity Division. To avoid EU penalties, FBD uses the GIS as part of its fishery bio-security procedures in response to an EU-issued audit. Bio-security, often called "hazard reduction via environmental modification," describes preventative steps done to limit the transmission of disease inside a facility (Plumb, 1992). Bio-security, or the safeguarding of cultured animals against contamination and the prevention of the spread of illness across borders, has taken on more significance as aquaculture production methods have intensified (Sachin O. Khairnar, et.al.,2018).

This research aims to better understand the role of geographical context in the care of aquatic animals on 30 farms specialising in decorative aquaculture in the Sungai Siput district of Perak. As a means of organising the data, we will employ geospatial information systems and remote sensing to develop a classification scheme. This study will analyse the farmers' efforts both on and off the farm, and when complete, ornamental fish import restrictions in Malaysia will be eliminated. Through the collection of demographic data on the farmers and the creation of a compartmentalization system using GIS spatial analysis, this study aims to identify the spatial characteristic variables in terms of aquatic animal health management on 30 ornamental aquaculture farms in Sungai Siput, Perak. Ultimately, this research will help Malaysia use the web-based GIS system as one of the tools and references for fish health monitoring.

High-precision, well-managed, and up-to-date data from a variety of sources are required to accurately identify farmers, farms, and geographical features of farming activities, as stated by Ruslan et al. (1998). A database that contains all of the information gathered throughout the study can be used for this purpose. We may also generate, modify, analyse, and display spatial information using GIS and remote sensing. As a result, GIS is dependent on both geographical and non-spatial data, both of which must be kept current for the system to be useful (Ruslan et al., 1998). The term "remote sensing" refers to the practise of gathering data about an area from afar using sensors placed at sea, in the air, or on land (Haines-Young, 1994). To wit: (Haines-Young, 1994). Remote sensing is a method of gathering information about a target region without physically visiting there. Some of the most common remote sensing instruments are drones, satellites, and aeroplanes. The practise of collecting data about Earth from space or aircraft is called "remote sensing," and it's both an art and a science. Images captured by sensors can be improved, analysed, and displayed with the help of dedicated software. In this research, remote sensing imagery is included into a GIS.

Details Experimental

Materials and Procedures

In order to learn where ornamental fish growers in Sungai Siput, Perak, are located, a survey and field verification were done. According to current research, Sungai Siput in the state of Perak now has the largest concentration of ornamental fish exporters in all of Malaysia. It was thought that ornamental fish farmers in Sungai Siput, Perak, would have a wide range of agricultural passions. This study was carried out to investigate how ornamental fish farmers in Sungai Siput, Perak, evaluate the success of various farming practises that influence the economic worth of ornamental fish exported from the country.

But factors like personality, fish farm features, and location all play a role in whether or not someone decides to sign up. The connection between farm labour and a fish farm's bottom line demonstrates that the degree to which farm households rely on on-farm revenues may influence the distributional implications of agricultural policy in a country.

Ruslan (1996) proposed that spatial referencing data might be used to collect information on many geographical phases, such as election areas and infrastructure services areas, for the purposes of spatial analysis. Given that GIS projects can take a long time and a lot of money (typically about 80% of project funds), it is crucial to have a precise estimate of the time and resources needed for the research. So that the data may be verified and used successfully, GIS analysis needs to be completed faster.

In this research, we assess the quality of the spatial data we've gathered. To demonstrate the data distribution, a sample database was constructed using GIS, vector, and raster data models, as spatial data database types require a unique data model. The farm's location will be determined with the help of satellite imagery. In the future, scientists will be able to employ remote sensing to investigate desertification's root causes, monitor vulnerable areas over time, and measure the efficacy of environmental management strategies (Begni G.et. al 2005).

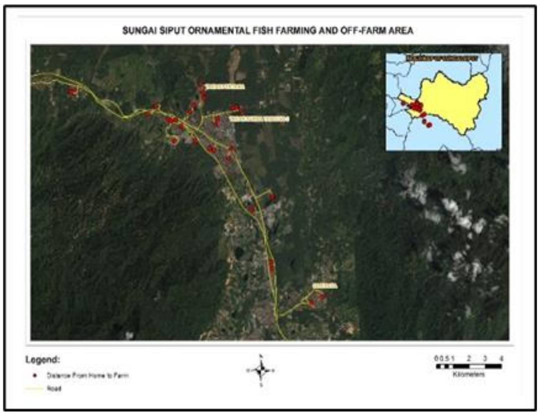

Fig 1: *Sungai Siput, Perak Ornamental Fish Farming Area*

Data Collection and Sampling

Ornamental fish breeders from Sungai Siput, Perak, took part in the study. Perak's Department of Fisheries surveyed a random sample of farmers in Sungai Siput for their latest census. Thirty persons were interviewed for this study, primarily through the use of a standardised questionnaire. Researchers used a questionnaire to learn how often ornamental fish producers work outside of the industry now.

However, the questionnaire's questions are organised, with two distinct types: those with multiple choice answers and those with simply true or false options. The only possible choices for a yes/no question are yes and no. Questions with multiple choices offer more than two answers, which is a nice benefit. The United States Department of Agriculture and the Malaysian Department of Survey created analogue maps for the alternative methodology (JUPEM). The acquired spatial data was then used to generate digital maps of the study area, detailing its administrative borders, land use, settlements, roads, rivers, and streams.

Descriptive Analysis

Descriptive analysis was used in this study to characterise the responses and associated data, as well as the variables' characteristics in terms of percentage distribution and frequency of the questioned data. The first phase in any statistical procedure is descriptive analysis since it provides a high-level overview of the data, aids in the identification of outliers and errors, and reveals relationships between variables.

Chi-Square Analysis

One way to illustrate a link between two category variables is through a chi-square analysis. There are two types of variables in statistics: numerical variables and categorical variables (categorical). Because of this, the chi-squared test gives you a single value to show the size of the gap between your observed counts and the counts that would be predicted if the population had no association at all. The equation is as follows:

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

The letter "c" in parentheses indicates the number of degrees of freedom. The result that was obtained was a "O," whereas the value that was projected was a "E." It's not very likely that you'll need to manually compute a crucial chi-square figure, so it's unlikely that you'll want to use this formula. In addition, the summation sign indicates that you are required to do a calculation for each and every data item that is contained within your data collection.

Spatial Analysis

A subset of geographical analysis known as spatial analysis, sometimes known as locational analysis, the purpose of which is to present patterns of human behaviour and their spatial expression in terms of geometry and mathematics, spatial analysis is also often known as locational analysis. Because it is anticipated that aquaculture will continue to grow, become more intensive, and increase production for the foreseeable future, it is essential to have a solid understanding of the spatial difficulties that are related with aquaculture (FAO, 2018).

For the purpose of organising and reporting data in a manner that enables it to be viewed either from a single point of view or from several points of view, spatial tools are necessary (G. Yucel-Gier et al., 2010). Through the use of spatial analysis, GIS generates geographical data; the information that this develops is more informative than data that has not been arranged. Numerous approaches to geographical analysis are possible thanks to the availability of statistical data and information gleaned from geographic information systems (GIS). A Geographic Information System (GIS) enables the interaction of attributes with geographic data in order to increase the accuracy of spatial analysis interpretation and prediction (Gupta, 2005).

When employing a GIS, an appropriate geographic method is chosen for implementation based on the needs of the end user, as stated by Burrough (2001). Because it integrates hardware, software, and data for collecting, storing, analysing, and displaying a wide variety of spatially connected information, GIS may provide researchers with an almost limitless amount of data (Foote and Lynch, 2015).

The geographical methodology selected will dictate the categorization and analytic techniques used. Geographic analysis is a set of methods for investigating geographical data, ranging from simple database queries to in-depth model research. When conducting spatial analysis, the physical position of the objects being studied can affect the outcomes. ArcGIS was used for all of the study's GIS needs. Because of its ability to store both object positions and attribute properties, the GIS software ArcGIS can be used to apply spatial analytic procedures. Fish pond development requirements can be better assessed with the help of satellite remote sensing and geographic information systems (GIS) than they can with just one of these tools alone (Ogunlade S., 2020). Sungai Siput, Perak served as the focal point for all geographical references in the collected data set, including observations about respondents' homes, farms, non-farm activities, and residential locations.

Results and Discussions

Descriptive analysis was used to assess the respondents' involvement in farming activities, proximity to urban centres, and quality of relationships. In this study, we employed the Chi-Square test to look at the connection between two different types of categorical variables. So, we ran some spatial analysis to figure out how far it was from the farmer's residence to the farm and how far it was from the farm to the next town.

Descriptive Analysis

According to Table 1, below, we can see how old the respondents were. In Sungai Siput, Perak, 40.0% of the population over the age of 40 engaged in agriculture; 30.3% of those between the ages of 31 and 40; 20.0% of those between the ages of 21 and 30; and 6.7% of those younger than 20. The following findings suggest that among the active farmers in Sungai Siput, Perak, there are also older farmers who rely on revenue from aquaculture operations and have no plans to retire from farming.

Table 1: *Participation in Off-farm Employment*

Age	n(30)	Percentage (%)
Less than 20 years old	2	6.7
21 to 30 years old	6	20.0
31 to 40 years old	12	40.0
More than 40 years old	10	30.3

Fish species tabled by responders who took engaged in fish farming in Sungai Siput, Perak Among the responders, 50.0% bred cyprinids such barbs, danios, goldfish, and koi; 43.3% bred poecilids; and 6.7% bred anabantids. Based on the data, we know that 15 out of the 20 farmers surveyed in Sungai Siput, Perak bred Cyprinids such Barbs, Danios, Goldfish, and Koi to satisfy local and international demand.

Table 2: *Type of Fish*

Type of Fish	n(30)	Percentage (%)
Cyprinids Barb/Danio/Goldfish/Koi	10	33.3
Poecilids	13	43.3
Anabantids	7	23.3

Chi-Square Analysis

Age and Off-farm

According to Table 3, 17 of the 30 respondents were 40 or older, 7 were 31 to 40, 4 were 21 to 30, and 2 were younger than 20. The data in this fictitious table supports the idea that older aquaculture producers are more likely to have careers outside the family business. There was no statistically significant correlation between farmers' ages and their likelihood of holding non-farm jobs (chi-square = 0.000, significance = 0.000, degree of freedom = 3). As a result, the null hypothesis is rejected.

Education and Off-farm

As can be seen in the hypothetical Table 3, the predicted association holds, and the frequency distributions do not follow a random distribution. As can be seen in the table, farmers are more likely to have non-farm occupations if they have more education. The correlation between education and off-farm work is statistically significant (chi-square = 36.916, 7 degrees of freedom, 0.000 level of significance), with the highest rate found among SPM holders and the lowest rate found among Degree holders. Therefore, we must reject the null hypothesis.

Income and Off-farm

As can be seen in the hypothetical Table 3, the predicted association holds, and the frequency distributions do not follow a random distribution. As can be seen in the table, farmers are more likely to have non-farm occupations if they have more education. The correlation between education and off-farm work is statistically significant (chi-square = 36.916, 7 degrees of freedom, 0.000 level of significance), with the highest rate found among SPM holders and the lowest rate found among Degree holders. Therefore, we must reject the null hypothesis.

Table 3: *Chi-Square Analysis*

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

Spatial Analysis

Home and the Farm

Table 4 and Figure 2 show the distances that residents of the survey area travelled to reach their respective farms. Fifty percent of the ornamental fish farmers in the town of Sungai Siput, Perak, all live within a ten-kilometer radius of their farms. The majority of those who answered our survey are looking for agricultural jobs in their local area. A farmer's ability to diversify his income by engaging in activities outside of farming is influenced by his location.

Table 4: *Home and the Farm*

Distance Between Home To Farm	n(30)	Percentage (%)
Less 10 km	15	50.0
11 to 20 km	12	40.0
21 to 30 km	3	10.0
More than 31 km	0	0

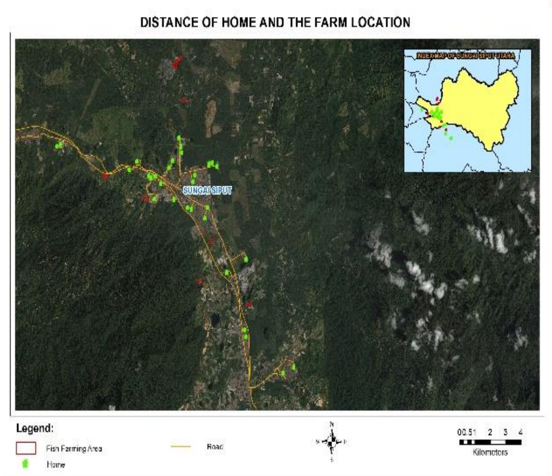

Fig 2: *Sungai Siput, Perak's Distance of Home and The Farm*

Home to Ornamental Fish Type and Off Farm

As can be shown in Table 5 and Figure 3, there is a correlation between distance from home and ornamental fish species in Sungai Siput,Perak. Fifty percent of the ornamental fish farms that raised Cyprinids such as Barb/Danio/Goldfish/Koi, Poecilids, and Anabantids were located within 10 kilometres of the aquarists' houses. Only 6.7% of Cyprinid farmers lived more than 30 kilometres from their farms, while the remaining 58.3% were located within 11-20 kilometres.

This discovery hints that people's desire to raise cyprinids, such as Barb/Danio/Goldfish/Koi, poeciliids, and anabantids, in captivity is influenced by their geographic location. Those who are keen in cultivating land are more likely to live in close proximity to a facility producing ornamental fish, which has practical implications in terms of both convenience and cost.

Table 5: *Home to Ornamental Fish Type*

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

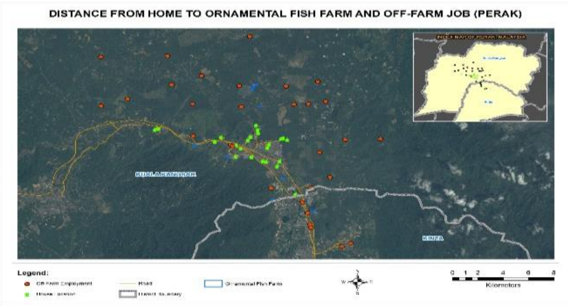

Fig 3: *Home to Ornamental Fish Type and Off-farm Job*

Home to the Nearest Town and Off-farm Employment Type

Table 6 and Figure 4 below detail the average travel time from Sungai Siput, Perak homes to the nearest town and the fish species that are bred in the area. According to the statistics, 26.3% of the farms that specialise in raising Cyprinids (Barb/Danio/Goldfish/Koi, Poecilids, and Anabantids) for ornamental purposes are located within 5 kilometres of a town and an alternative source of income. Cyprinid (Barb/Danio/Goldfish/Koi, Poecilid, and Anabantid) farmers were more likely to be located more than 11 kilometres from the nearest town, with 21.1% of those farmers residing between 6 and 10 kilometres from their home and off-farm work. Considering the convenience of city life in terms of supplies, transportation, and public facilities, it stands to reason that urban dwellers will be more likely to engage in aquaculture and produce some types of fish.

Table 6: *Home to the Nearest Town and Fish Type*

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

According to the results of this research, ornamental fish farmers in Malaysia can increase their income and standard of living by taking jobs outside the industry. That makes it easier to pinpoint things like agricultural jobs versus city jobs and other regional specifics. On the other hand, spreading one's employment risks across a number of different endeavours can help to steady one's earnings. For the purposes of farm monitoring, a database of farm sites was created, and spatial analysis was carried out.

Working outside the home to supplement farm income is often seen as a viable approach for keeping families afloat in rural areas. Employment outside of farming has been shown in multiple studies to be a useful supplement to farming and to reduce the rate at which people leave the industry. Yet it is contends that working outside the farm promotes structural transformation in agriculture.

In 2015, the European Union (EU) placed a fish embargo on goldfish and koi carp, which had repercussions for the industry as a whole. The FBD developed the BioDOF-Map system, which integrates spatial and non-spatial data, to solve the problem. It all came crashing down in 2015 when the European Union (EU) implemented a fish embargo on goldfish and koi carp. The FBD developed the BioDOF-Map system, which includes spatial and non-spatial information about ornamental fish farms, to deal with the problem. It has been shown that the BioDOF-Map system will allow the Malaysian government to gain access to and manipulate a great deal more information, particularly in the fields of aquaculture and agriculture, which will aid in the improvement of current policies and serve as a key input in strategic planning.

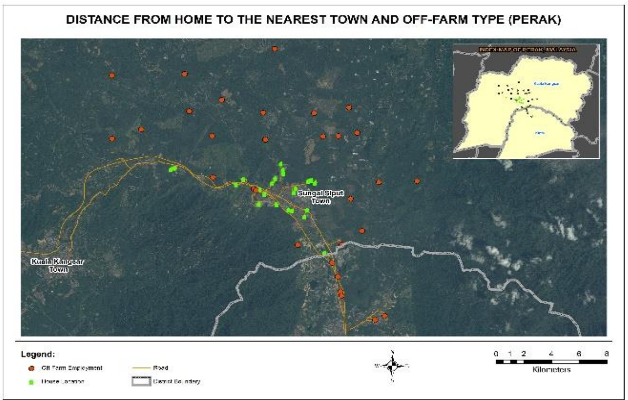

Fig 4: *Home to the Nearest Town and Off-farm Type*

Conclusions

This research suggests that ornamental fish breeders in Malaysia could benefit financially from taking on non-farm jobs. By better harmonising rural development goals with regional policies, rural areas can diversify their economies and the off-farm employment opportunities that come with them. This facilitates the identification of both on-farm and off-farm employment opportunities, as well as the identification of other geographic elements. On the other side, spreading your risk over a number of different activities, like several jobs, might help smooth out your income. A database of agricultural locations was compiled, and spatial analysis was carried out, in order to keep an eye on things from afar.

In 2015, the EU placed a fish embargo on goldfish and koi carp, which had repercussions for the industry as a whole. The FBD developed the BioDOF-Map system, which integrates spatial and non-spatial data, to solve the problem. The EU's ban on goldfish and koi carp in 2015 did have a ripple effect throughout the sector. The FBD created the BioDOF-Map system, which includes spatial and non-spatial data on the ornamental fish producers, to help with this problem.

There are many important uses for GIS web-based apps. They have several benefits, one of which is that you can do whatever you need to do on a web browser rather than having to download and run software. Web apps are increasingly important to modern businesses thanks to cloud computing. Thusm, it has been shown that the BioDOF-Map system will allow the Malaysian government to gain access to and manipulate a great deal more information, particularly in the fields of aquaculture and agriculture, which will aid in the improvement of current policies and serve as a key input in strategic planning.

Acknowledgments

The authors would like to thank:
YBhg. Datuk Haji Mohd Sufian bin Sulaiman
Deputy Director-General (Management), Department of Fisheries malaysia
YBhg. Dato' Mohd Mohtar bin Mahamud
Deputy Director-General (Development), Department of Fisheries malaysia
Tuan Haji Azlikamil Napiah
Director General, Malaysian Space Agency (MYSA)
YBrs. Mr Adnan bin Ismail
Deputy Director-General (Research and Development), Malaysian Space Agency (MYSA)

We'd also like to thank everyone who helped with this study behind the scenes, from research assistants to field workers to computer and data entry specialists.

References

Adams Ceballosa Jorge David Dresdner-CidbMiguel ÁngelQuiroga-Suazob (2018). Does the location of salmon farms contribute to the reduction of poverty in remote coastal areas? An impact assessment using a Chilean case study Volume 75, February 2018, Pages 68-79.

Amod Ashok Salgaonkar, Trivesh Suresh Mayekar, Avinash Rambhau Rasal, Kiran Rasal, Balkrishna Hotekar, Rakesh Jadhav, Amar Gaikwad (2018). Applications Of Remote Sensing (RS), Geographical Information System (GIS) & Global Positioning System (GPS) In Fisheries, Retrieved August 18, 2018

Annual Fish Statistic Malaysia (2017). https://www.dosm.gov.my [accessed Aug 24 2018].

Ayyappan, S. and Krishnan, M. 2004. Fisheries sector in India: Dimensions of Development. Indian Journal of Agricultural economics 59(3): 392-412.

Bhatta, G.D. & Doppler, W. (2010). Farming Differentiation in the Rural-urban Interface of the Middle Mountains, Nepal: Application of Analytic Hierarchy Process (AHP) Modeling. Journal of Agricultural Sciences, 2(4), 37-51.

Bhatta, G. D. (2010). Socio-economic and Spatial Assessment of Smallholder Peri-urban Farming in Middle Mountains of Nepal. Weikersheim, Germany: Margraf Verlag.

Burrough, P.A.(1986). Principles of Geographic Information Systems for Land Resource Assessment. Monographs on Soil and Resources Survey No. 12, Oxford Science Publications, New York.

Burrough, P.A.(1986).Principles of Geographical Information Systems for Land Resources Assessement. Oxford: Clarendon.

Blancou, J., (1996). Preface. In: Preventing the Spread of Aquatic Animal Diseases. (Editor B. J. Hill, and T. Hastein) pp 377-79. Vol. 15, office International des Epizooties, France.
Chao, N.L., P. Petry, G. Prang, L. Sonneschien, and M. Tlusty (2001). Conservation and Management of Ornamental Fish Resources of the Rio Negro Basin, Amazonia, Brazil-Project Piaba. Manaus, BR: Editora da Universidade do Amazonas (EDUA).
Chapman, F.A., S.A. Fitz-Coy, E.M. Thunberg, and C.M. Adams (1997). United States of America trade in ornamental fish. Journal of the World Aquaculture Society 28:1–10.
Clarke, K.C. (1995). Analytical and Computer Cartography. Edited by K. C. Clarke (2nd ed.), Prentice Hall Series in Geographic Information Science. Upper Saddle River, NJ: Prentice Hall.
Clarke, K.C. (1997). Getting Started with Geographic Information Systems. Upper Saddle River, NJ: Prentice Hall.
DOF Malaysia, 2012. Annual Fisheries Statistics (Volume 1), 25p, http://www.dof.gov.my/fishery-statistics, (June 26, 2014).
DOF Malaysia, 2016. Annual Fisheries Statistics (Volume 1), 25p, http://www.dof.gov.my/fishery-statistics [accessed Aug 24 2018].
Dey, V.K. 2010. Ornamental fish trade – Recent trends in Asia. In Souvenir, ornamental Kerala, 2010. Department of Fisheries, Government of Kerala, India, 39-45.
FAO, Food and Agriculture Organization of the United Nations. 1996-2005. the numbers represent the average unit value of imports for 1994–2003. FAO Yearbooks 1996 to 2005, Fishery Statistics, Commodities Volumes 83–97. FAO:Rome, Italy.
Ford, D., (1995). Research and development within the industry. Official Publication of Ornamental Fish International 10: 12-14.
Goodwin, B. & Mishra, A. (2004). Farming Efficiency and the Determinant of Multiple Job holding by Farm Operators. American Journal of Agriculture Economics, 80, 722-729.
Gurumayum, S.D. and Goswami, U.C. (2002). Ornamental fishes of Manipur developmental scope. Fishing Chimes 22(9): 46-50.
Haining, R. (1990). Spatial Data Analysis in the Social and Environmental Sciences, Cambridge University Press, Cambridge.
Haines-Young R (1994) Remote sensing of environmental change. In: Roberts N (ed) The changing global environment. Blackwell, Oxford, pp 22–43Google Scholar
Itzkovich, J. (2011). Global trade structure of ornamental fishes – an overview. Fishing Chimes 30(10&11): 76-77.
Laurance, W. F., K. R. McDonald, and R. Speare, (1996). Epidemic disease and the catastrophic decline of Australian rain forest frogs. Conservation Biology, 10: 406-13.
Lee, K.Y.K. (2005). Ornamental fish trade in Singapore, Paper presented in the conference on ornamental Kerala, 2006, Souvenir, Department of Fisheries, Government of Kerala, Thiruvananthapuram. 19-22pp.
Leeuwen E.V., Dekkers, J. & Rietveld, P. (2008). The Development of a Static Farm Level Spatial Microsimulation Model to Analyse On- and Off- Farm Activities of Dutch Farmers. Paper for the 3rd Israeli- Dutch Regional Science Workshop, 4-6 November 2008, Hebrew University, Jerusalem, Israel.
Lovatelli A., Aguilar-Manjarrez J., & Soto D. (2013). Expanding mariculture farther offshore: Technical, environmental, spatial and governance challenges. FAO Technical Workshop (p. 73). Orbetello, Italy: FAO Fisheries and Aquaculture Department.
Lightner, D. V., (1996). Epizootiology, distribution and the impact of international trade of two penaeid shrimp viruses in the Americas. In: Preventing the Spread of Aquatic Animal Diseases, (Editors B. Hill, and T. Hastein), Review Scientific et Technique. Once International des Epizooties, Paris, France Diseases, (Editors B. Hill, and T. Hastein), Review Scientific et Technique. Paris, France. Manton, KG, Stallard, E, Woodbury,

MA, and Dowd, JE. "Time-varying covariates in models of human mortality and aging: multidimensional generalizations of the Gompertz." J Gerontol 49, no. 4 (July 1994): B169-B190.

Messer, N., and P. Townsley. 2003. Local Institutions and Livelihoods: Guidelines for Analysis. Rural Development Division, Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/DOCREP/006/Y5084E/y5084e00.HTM; Module 3: "Doing the Community Profile."

Plumb, J. A. (1992). Disease control in aquaculture. In Diseases in Asian Aquaculture I, M.Shariff, R. P. Subasinghe and J. R. Arthur, eds. (Manila, Philippines: Fish Health Section, Asian Fisheries Society), pp. 3-17.

Rabanal, H.R. (1986). Status and prospects of shrimp farming in the Philippines. ASEAN/UNDP/FAO Regional Small-Scale Coastal Fisheries Development Project, Manila, Philippines. 29 p.

Rigaux, P., Scholl, M. & Voisard, A. (2002). Spatial Database with Application to GIS. San Francisco, USA: Morgan Kaufmann Publishers.

Rubino M. (Ed.). (2008). Offshore aquaculture in the United States : Economic considerations, implications & opportunities. Silver Springs, MD, USA: U.S. Department of Commerce. NOAA Technical Memorandum NMFS F/SPO-103.

Ruslan, R. & Noresah, M. S. (1998). Sistem Maklumat Geografi, Dewan Bahasa dan Pustaka.

Star, J. L. & Estes, J.E. (1990). An Introduction to Geographic Information System, Prentice-

Hall, Englewood Cliffs, N.J.Shabir Ahmad Dar, Mohd. Ashraf, Mishal. P & A.M Najar (2018). Ornamental Fish Culture: Creating A Niche In The Economy, Retrieved August 18, 2018 from http://aquafind.com/articles/Ornamental_Fish_Culture.php

Sachin O. Khairnar, Kiran Mali, Pankaj Kapse, Abhay Deshmukh and Bhavesh Solanki (2018). Bio- security: Its Application In Shrimp Farming. Retrieved August 18, 2018 from http://aquafind.com/articles/Shrimp-Bio-security.php Management of aquarium ("ornamental") fish.

Tlusty, M. 2001. The benefits and risks of aquacultural production for the aquarium trade.

Aquaculture 205: 203-215. Ukaonu, S.U., Mbawuike, B.C., Oluwajoba, E.O., Williams, A.B., Ajounu, N., Omogoriola, H.O., Olakolu, F.C., Adegbile, O.M. and Myade, E.F. (2011). Volume and value of ornamental fishes in the Nigerian export trade. Agriculture and biology journal of North America 2(4): 662-664.

V K Dey (2016). The Global Trade in Ornamental Fish Infofish. International 4/2016. www.infofish.org