The downside of tilapia farming

The effect of tilapia farming on Tena's ecosystem services and local communities: an analysis of community perspectives

Iris Jonker
MSc Thesis in Environmental System Analysis
May 2023

Supervised by: Solen le Clech
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Environmental Systems Analysis

WAGENINGEN UNIVERSITY

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Supervisor(s):

1) Solen le Clech
solen.lechlech@wur.nl
+31639267128

2) Jorge Celi
jorge.celi@ikiam.edu.ec
+593-6-299-9160

Examiner:

1) Jannik Schultner
jannik.schultner@wur.nl

Preface

Since I was young I have been intrigued by nature and especially the animals that live in it. When I had the opportunity to go abroad in my gap year after high school I went to South Africa and volunteered in two different nature reserves close to Hoedspruit for two months. Here I saw first-hand the impacts of human activities on wildlife, both indirectly through droughts caused by climate change and directly through poaching. This experience ignited my passion for wildlife and nature conservation. I decided to study Environmental Sciences at the Wageningen University and Research to do more research on the relations between humans and ecosystems and contribute to the prevention of loss of wildlife and nature.

When choosing a thesis topic I kept this in mind and chose to look for a subject combining the natural and social side of environmental problems. Through Pim van Hooft I got into contact with Jorge Celi in Ecuador and together we brainstormed and came up with the topic of the impacts of tilapia farming on river ecosystem services and local communities in Tena, Ecuador. I believe involving local communities is essential to gain a realistic and complete overview of the problems at hand and to achieve lasting improvements

Throughout my thesis I have had support from different people that I would like to thank. Firstly, I would like to thank both of my supervisors: Solen le Clech and Jorge Celi. Solen was very supportive during the process and challenged me intellectually during our meetings which made me push harder and motivated me to produce the best version of my thesis. Jorge was very supportive as well and provided me with a lot of help during my time in Ecuador. He was always interested and available to help and brought me into contact with students who helped me with my fieldwork. Jorge was always positive which also excited me to put a lot of effort in my research.
I would not have been able to perform my fieldwork without the help of students from Universidad Regional Amazónica Ikiam in Tena who helped me with conducting the interviews and questionnaires. Their help was fundamental for my fieldwork and research, so a big thank you to: William Quezada, Gabriel Criollo, Tania Mier, Jonier Merizalde, Ariana Brito, Denisse Castillo, and Kevin Luna. I would also like to thank Axel Makkinga who helped me with the analysis of the results in SPSS, even during the Christmas holidays.
I would like to express special gratitude to Domenica Brito and her family who have made me feel at home in a different country and welcomed me with open arms into their family, also during Christmas and New Year. It was not always easy being by myself on the other side of the world but their warmth and kindness made it easier and left me with some of my favourite memories of Ecuador.
Lastly, I would like to thank my family, friends, boyfriend, and housemates for their support during my thesis, both when I was in Holland and Ecuador!

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Summary

Human activities have led to degradation of ecosystems and threatened the ecosystem services. One of these human activities was tilapia farming next to rivers. Tilapia farming could bring financial benefits and play a role in fighting food insecurity. The popularity of farming tilapias, native to Africa, came from the fast-growing rates of the species, affordability, and high values of protein. However, tilapia farming could also have negative environmental consequences such as water pollution and the displacement of native fish. These adverse environmental developments have put pressure on the ecosystem services provided by river ecosystems. Ecuador was one of the main tilapia producer countries. In Tena, a canton in Ecuador, farming took place in ponds in riverbanks of the rivers "Rio Tena" and "Rio Pano". The effect this had on the ecosystem services and the local communities that were dependent on the services had not been researched thoroughly. Therefore, this study researched the effect of tilapia farming of tilapia farming on Tena's river ecosystem services and local communities, and causes of this effect, according to local communities' perspectives.

A literature review was used to identify the ecosystem services provided by the rivers Tena and Pano and their riverbanks, which were: provisioning of fish for food, water for human consumption, water for domestic use, water for agriculture, regulation of the carbon cycle, flood control and mitigation, cultural identity, aesthetics, recreation, and tourism. Semi-structured interviews were used to identify the farming practices of tilapia farming. The identified ecosystem services and farming practices were used in a questionnaire to obtain: the perceptions of local communities on the importance of the ecosystem services, the effect of tilapia farming on the ecosystem services, the contribution of farming practices to ecosystem change, and alternative practices.

Despite limitations in the chosen ecosystem services and questionnaire challenges, the study revealed that the rivers and riverbanks had great significance to local communities. The cultural services were the most important to local communities and the communities were also the most dependent on them for their wellbeing, largely due to the indigenous background of the local communities. The provisioning services were second-most important, followed by the regulating services.
Community members observed a negative effect of tilapia farming on all ecosystem services. The biggest negative effect was observed for the provision of food for people, followed by aesthetics, recreation, regulation of the carbon cycle, tourism, cultural identity, and flood control. According to community members tilapia farming has led to a decrease in native fish, murky river waters, health problems when swimming in the river, a loss in culture and loss in tourism.
The negative effects were attributed to the farming practices of tilapia farming. In general, all farming practices were considered to have had a negative contribution to ecosystem service change. The most adverse impact on the ecosystem services was caused by the discharge of wastewater from farming into nearby streams, followed closely by the food given to the tilapias. Both practices contributed to river contamination and loss of ecosystem services. Alternative practices to minimize the negative effects were wastewater treatment, alternative feed for tilapias, farming further from the river, socialization of the problem and governmental support.

The study demonstrated the significance of incorporating the perceptions of local communities while evaluating the impact of tilapia farming on the river ecosystem services and local communities. Local communities were dependent on the river ecosystem services and were therefore also dependent on the health of the river ecosystem. By providing alternative management practices that minimize the negative impacts of tilapia farming, policymakers could better enforce existing laws and regulations with the goal of achieving sustainable tilapia farming practices that support both the ecosystem health and well-being of local communities.

1.Introduction

1.1 Background of the study

River ecosystems provide humans with important benefits, such as the provision of water, fish as food supply, and cultural value (Böck, Polt, & Schülting, 2018). River ecosystems have unique characteristics and provide a variety of ecosystem services. Ecosystem services are contributions, in the form of goods and services, of the ecosystem to society and are essential for human wellbeing (SEEA, 2012). Worldwide ecosystems are under threat from human activities, resulting in the degradation of ecosystems and putting pressure on its ecosystem services (Adla et al., 2022).

An example of a human activity causing degradation of the ecosystem is tilapia farming in riverbanks. Tilapia (*Oreochromis niloticus*), a species indigenous to Africa and the Middle East, is the second most farmed fish in the world (Canonico et al., 2005) (Santafe-Troncoso & Loring, 2021). Approximately 98% of tilapia production is believed to take place outside of its native range (Champneys, Genner & Loannou, 2020). The last decade, the production has quadrupled (Prabu, Rajagopalsamy & Ahilan, 2019). Its popularity in farming comes from the affordability, fast-growing rates of the species, easy adaptation to different environments and the high values of protein the species contains (Santafe-Troncoso & Loring, 2021). Due to these advantages, in combination with the fact tilapias can be cultivated in a variety of settings, from small backyard ponds to large-scale farms, tilapias are commonly referred to as the "aquatic chicken" (Canonico et al., 2005). Tilapia farming can also bring financial benefits to society such as job opportunities for the local population (Barroso, Munoz & Cai, 2019). Furthermore, tilapia farming has the potential to play a big role in the fight against food insecurity (Prabu, Rajagopalsamy & Ahilan, 2019).

However, as mentioned before, tilapia farming can have negative environmental consequences. Negative consequences includes pollution of the water through regularly flushing the ponds, resulting in wastewater draining into the nearby waterbody (Seafood watch, 2022). Furthermore, when fish escape their ponds, it can lead to the spread of diseases to wild fish and the species becoming invasive (Santafe-Troncoso & Loring, 2021).
The adverse environmental developments do not only have a negative impact on the ecosystem but also put pressure on the ecosystem services provided by the rivers and riverbanks. Pollution of the rivers caused by tilapia farming can result in the deterioration of water used for human consumption, a provisioning ecosystem service of the river (Martinez-Porchas & Martinez-Cordova, 2012). Another example of a negative effect is the displacement of native fish through the introduction of tilapia, an exotic species (Martinez-Porchas & Martinez-Cordova, 2012).

In Ecuador, concerns have been raised about the adverse impacts of tilapia farming. Currently, tilapia cultivation covers an area of 2000 hectares in Ecuador, which is one of the main tilapia producer countries (FAO c, 2022) (FAO b, 2022). From the country's total aquaculture production of 464500 tonnes in 2017, 23050 tonnes were from freshwater tilapia (FAO a, 2019). The majority of the total production was related to whiteleg shrimp, a production of 435000 tonnes (FAO a, 2019). In Napo, a province in Ecuador, tilapia can easily be found in the wild despite it being an exotic species.
The farming takes place in ponds in riverbanks of the rivers "Rio Tena" and "Rio Pano". Rains and flooding have caused tilapia to escape into the rivers from their ponds (Santafe-Troncoso & Loring, 2021). This has raised concerns on the effect it will have on the native fish biodiversity and human health. Local people have already argued that native fish are more difficult to find due to the invasive nature of tilapia and that during fishing, more tilapias are being caught than native fish (Santafe-Troncoso & Loring, 2021). The cultivation of tilapia fish was adopted towards 1995 in Ecuador and the government has been promoting the cultivation (FAO c, 2022). In April 2013, the Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP) distributed 10 000 tilapia fry to the

community Santa Rosa, in the Tena canton. This initiative was aimed at boosting production, sales and enhancing ecotourism activities (Ministry of Agriculture and Livestock, 2013).

Studies have explored the effects of tilapia farming or other kinds of fish farming, such as shrimp, on the ecosystem (Vincente & Fonseca-Alves, 2013) (Ashton, 2010). However, the effect on local communities through changes in ecosystem services provision has not been researched thoroughly. One study has looked into how tilapia farming has affected the traditional cuisine of local communities in Napo, but it has not looked into other ecosystem services (Santafe-Troncoso & Loring, 2021).

To assess the effect of tilapia farming on local communities through changes in ecosystem services provision, information on the provided ecosystem services by the river ecosystem and their importance to local communities is necessary. Currently, information on the ecosystem services provided by the rivers and riverbanks in Tena is lacking. Studies have explored the ecosystem services provided by forests, pasturelands and croplands and their importance in the Amazon region but have not looked into river ecosystem services and their importance (Montoya et al., 2019).

Besides studying the effects on ecosystem services and local communities, research should be done into which alternative management practices for tilapia farming can be implemented minimize the negative impacts of tilapia farming on the ecosystem and local communities. Current studies have looked into the sustainable farming of tilapia but have not included perspectives of local communities (Godoy et al., 2022).

1.2 Purpose of the study

This research answers the question: What is the effect of tilapia farming on Tena's river ecosystem services and local communities and what is causing this effect, according to local communities' perspectives? Through answering the research question, the aim is to provide recommendations to improve tilapia farming practices to policy makers to minimize the negative effects on the ecosystem services and communities. The recommendations are essential to ensure the wellbeing of local communities that are dependent on the river's ecosystem services. Once identified, these recommendations can also be applied to other areas, where local communities are experiencing similar problems from tilapia farming on the ecosystem services and their wellbeing. The main research question will be answered through answering the following sub-research questions.

1.3 Research questions

1. What are the ecosystem services provided by the river Tena and Pano and their riverbanks?
2. Which ecosystem services are perceived to be the most important to Tena's local communities?
3. What is the observed effect of tilapia farming on the ecosystem services provided by the river Tena and Pano and their riverbanks?
4. What is the perceived contribution of tilapia farming practices to ecosystem service change and what are possible alternatives?

When talking about the river Tena and the river's ecosystem services, this includes the river itself and its riverbanks. This is because the tilapia farming takes place in the riverbanks of the river Tena and therefore also has an effect on the ecosystem services provided by the riverbanks (Santafe-Troncoso & Loring, 2021).

2. Methodology

This chapter will provide information on the conceptual framework, the study area, the research methods used in this research and on how these methods have contributed to answering the research questions.

2.1 Conceptual framework

Although rivers are a small part of the world's surface water, they are important producers of ecosystem services (Limburg, 2009). There are different classifications of ecosystem services. This study uses "The Common International Classification of Ecosystem Services" (CICES). The CICES separates the ecosystem services into three categories and provides an explanation on what these three categories mean, and which ecosystem services are included in the categories (European Environment Agency, 2022). The categories are provisioning, regulating and cultural services. Provisioning services are material/tangible outputs from ecosystems including food, water, and other resources (Böck, Polt, & Schülting, 2018). Regulating services are services provided by ecosystems based on the regulating capacity of ecosystems, such as carbon sequestration (Böck, Polt, & Schülting, 2018). Cultural ecosystem services arise from the way people interact with nature (Böck, Polt, & Schülting, 2018). They are non-material benefits people obtain from ecosystems and include aesthetic, spiritual and psychological benefits (Böck, Polt, & Schülting, 2018).

This study uses the conceptual framework of ecosystem services and the Economics of Ecosystems & Biodiversity. The framework shows that the ecosystem services arise from the function and processes of ecosystems and connect them to the ecological and socio-economic benefits for society (TEEB, 2010). Consequently, the framework is suitable for evaluating the impacts of changes in ecosystems on human wellbeing. The framework can be applied to river ecosystems. For instance, when a river is healthy, it performs various functions such as water passage (function). This function results in an ecosystem service such as flood protection (service), which ultimately benefits humans (benefit). The benefits to humans can be assigned a certain value, whether monetary or non-monetary.

The main focus of this study is on the provision of ecosystem services, rather than the demand for them. The provision of ecosystem services in my study refers to the capacity of the ecosystem to provide goods and services to humans, such as fish and recreation opportunities. The demand of ecosystem services refers to the human desire or need for the goods and services provided by the ecosystem. This study specifically focuses on the provision of ecosystem services as changes in the provision of the ecosystem services indicate the impacts of tilapia farming on ecosystem services and subsequently on human wellbeing.

2.2 Study area

In the east of Ecuador the province of Napo is located. The province contains the Tena canton (figure 1) in which the study area is located.

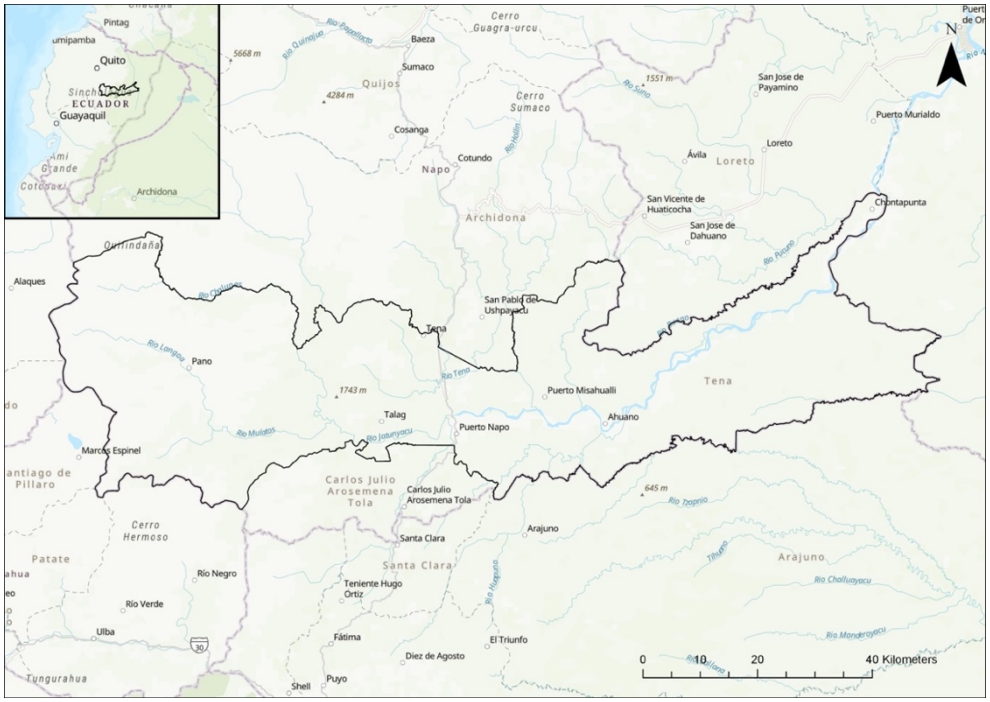

Figure 1: The Tena canton within Ecuador (World topographic map ESRI)

The area surrounds the city of Tena with its rivers Tena, Pano and Misahualli. The study area includes a community in the south of the city of Tena and six communities to the left of the city (figure 2). The city has approximately 44 135 inhabitants. Together with the communities to the left of the city it is estimated that the area contains 44 650 inhabitants (Tena Municipal Government, 2023).

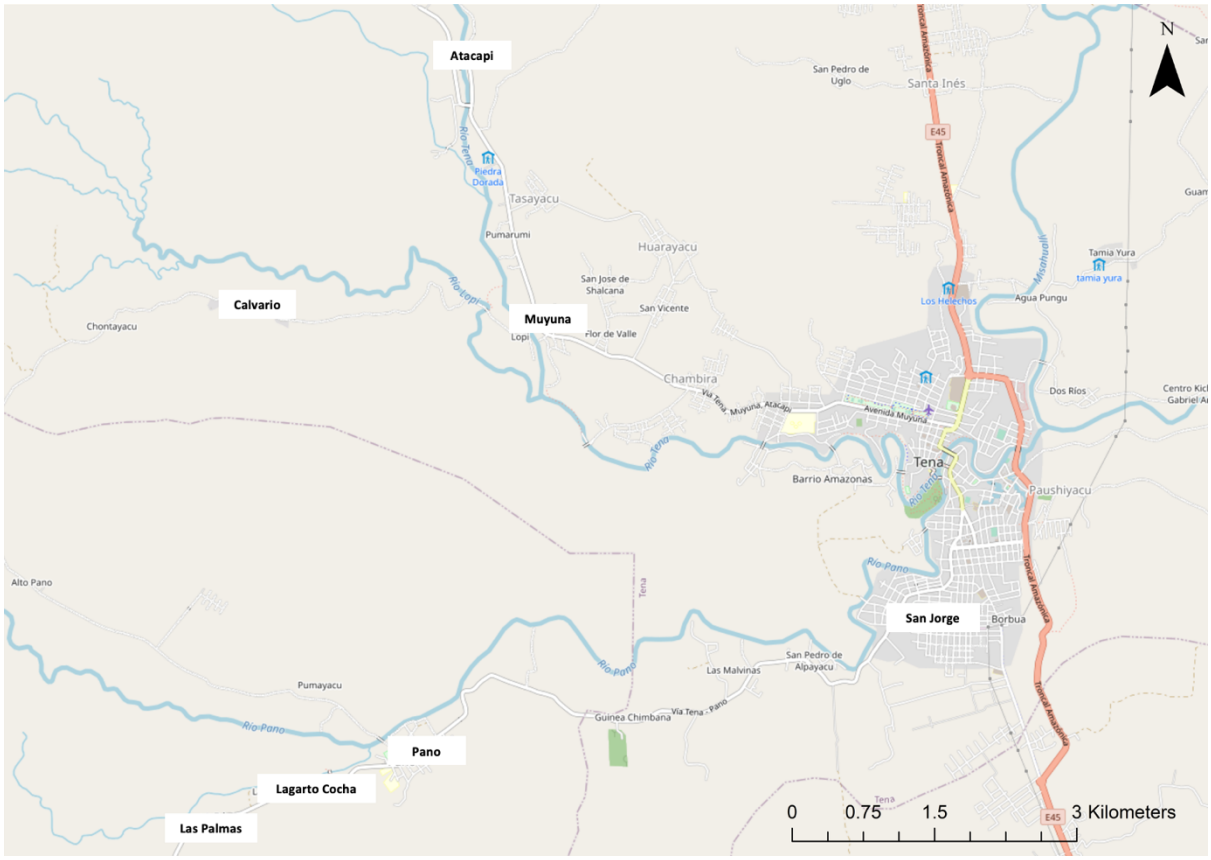

Figure 2: The location of the communities where the questionnaires were collected (World topographic map ESRI)

The area is located in the Amazon region of Ecuador. It is situated at around 600m above sea level and there is rainfall all year-round with an average rainfall of 275mm a month. The average annual temperature is 25 degrees, with the lowest temperatures measured in June and July and the highest in December and January (Tena Municipal Government, 2023).
The informal working sector has a big impact on the local economy of Tena, which can be seen through the commerce taking place on the streets by the street vendors. Tilapia farming also has a big impact on the economy. There is no data available on the exact number of tilapia farms in Tena but it is called the aquatic chicken and many people have a pond in their back garden (Tena Municipal Government, 2023).

2.3 General overview of research approach

A literature study, semi-structured interviews, a questionnaire, and statistical analysis have been used to gather and analyse data for this research. Figure 3 shows the different methods with corresponding data and how both have led to the desired results. At the start of the research, a literature study was done to identify the ecosystem services provided by the river Tena and Pano (RQ1). Then, semi-structured interviews were conducted with tilapia farmers to identify the management practices used to farm tilapia. The identified ecosystem services, the results of the semi-structured interviews and research into similar studies were used as input for the questionnaires. The questionnaires were analysed with SPSS and provided data on the perceived importance of the ecosystem services (RQ2), the observed effect of tilapia farming on the ecosystem services (RQ3) and the perceived contribution of tilapia farming practices to ecosystem service change and alternative management practices (RQ4). This contributed to answering the second, third and fourth research question.

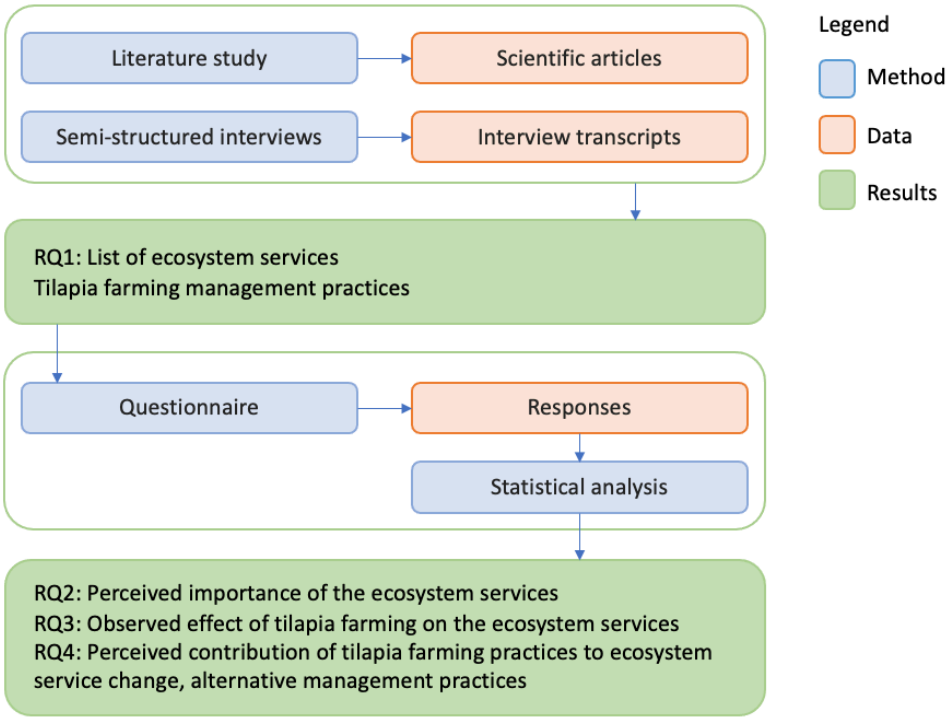

Figure 3: General overview of the methods, data, and results. The boxes with green lines indicate methods and data that belong together and lead to a certain result. The arrows show the order of the research approach and what it has led to

2.4 RQ1 Identification of ecosystem services

For the identification of the ecosystem services of the river Tena and Pano, a literature study was performed. The search queries in table 1 were used for this. The literature was searched for in Google Scholar and the online WUR Library. Articles containing the search queries in the text were used to identify the ecosystem services.

This research does not include ecosystem services gained from tilapia farming. This means, for example, that for the ecosystem service of food provisioning the native fish are included and not the tilapias or the farming of tilapia. This is to be able to identify how tilapia farming has affected the ecosystem services after its introduction. Besides the use of scientific literature, grey literature was used to identify the ecosystem services. Both the scientific literature and grey literature were not only searched for in English but also Spanish, as many useful articles and websites concerning the case study region or freshwater ecosystems in Ecuador have been written in Spanish.

Based on the literature research, the identified ecosystem services were included in the questionnaire. However, through conducting the questionnaire, additional ecosystem services were identified. The additional ecosystem services were added to the results chapter alongside the previously identified ecosystem services through literature research.

Table 1: Search queries used for the identification of the ecosystem services

Ecosystem services OR River ecosystem services OR Freshwater ecosystem services OR River resources OR River benefits	AND	Ecuador OR Tena OR Napo OR River ecosystems

2.5 Identification of management practices

The management practices of tilapia farming were identified through semi-structured interviews with tilapia farmers. The interviews contained questions on the purpose of the farming, the size of the farm, the process of the farming, the location of the farm and the water used for farming (section A.1, Appendix A). The interview questions were formulated with the help of two students from “Regional College Amazon Ikiam” (IKIAM) who are native Spanish speakers and have experience with fieldwork in Ecuador. This was to make sure the questions were in good Spanish and in understandable language to the interviewees as some people from rural communities do not understand scientific language.

Five semi-structured interviews of around seven minutes were done, three of those were with farmers who farmed tilapia for commercial purpose and two were with farmers who farmed for personal consumption. Due to time constraint and farmers not present or not wanting to be interviewed, not more than five interviews were done. The locations of the tilapia farms included in the interviews can be seen in the map below (figure 4). The tilapia farmers were selected based on the scale of farming and their location: the distance to the river and which kind of river. This was done to identify if those factors influenced the way of farming or if the farming was the same and therefore if the effect on the different river ecosystems might also differ. The tilapia farms included in the interviews differed in distance to the rivers Tena, Pano and Misahualli. The distance varied between 4m and 150m to the river. The river Misahualli was not included in the remainder of the research. Due to time constraint, river Tena and Pano with their surrounding communities were chosen.

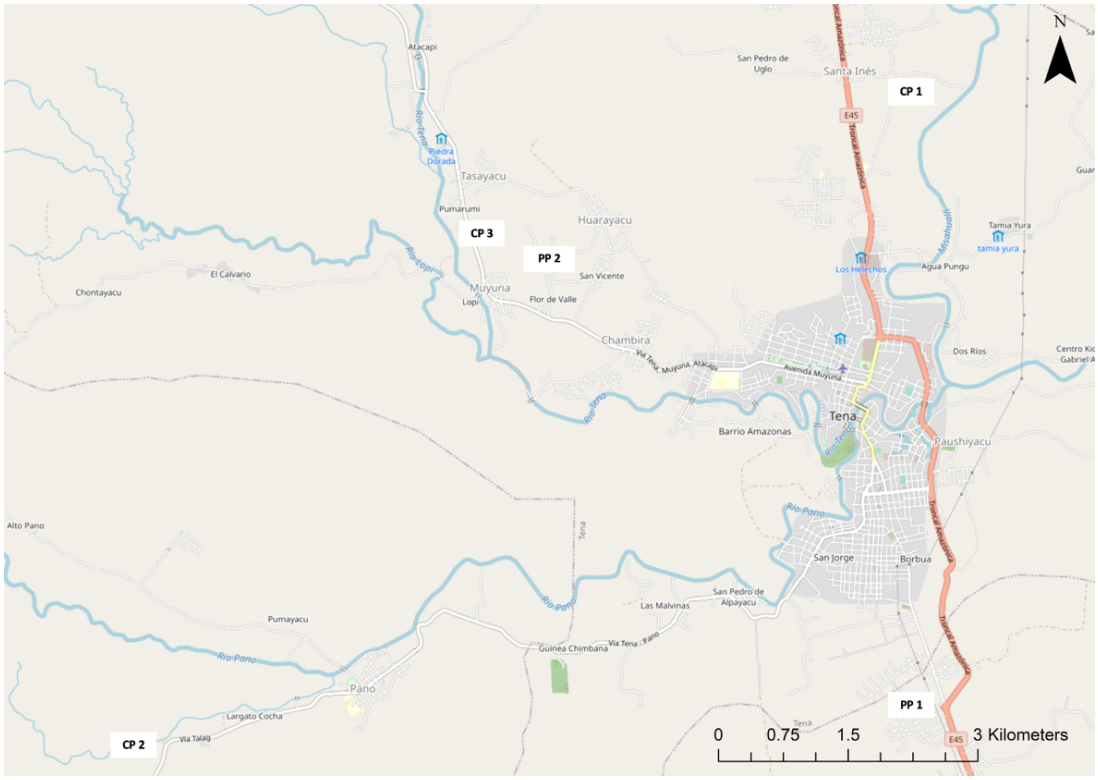

Figure 4: Locations of interviewed tilapia farms. CP1 = Commercial pond 1. CP2 = Commercial pond 2. CP3 = Commercial pond 3. PP1 = Personal pond 1. PP2 = Personal pond 2. (World topographic map ESRI)

The interviews were performed by the two students who helped with the formulation of the questions and me. All interviews were recorded. They were then transcribed in Spanish through Sonix, a website that transcribes audio files. From the recordings and transcriptions, English summaries were made with the help of one of the students. The transcripts of the interviews, as well as the English summaries of the interviews can be found in Appendix A. The interviews were used in chapter 2 to provide a general idea of the process of tilapia farming. They were also used as a basis for questions on management practices in the questionnaire.

2.6 RQ2, RQ3 & RQ4 obtaining perceptions of local communities

A questionnaire was used to gather information on the observed effect of tilapia farming on the ecosystem services, the observed effect of specific management practices on ecosystem services, the perceived importance of the ecosystem services and current/future threats for tilapia farms. The responses of the questionnaires were analysed in SPSS through different statistical analyses and tests.

2.6.1 Questionnaire data collection

The questionnaire (Appendix C) was made using examples of other similar studies and previous projects at the Wageningen University and Research, such as the European Workshop project on the Waddensea area. Questions were first formulated in English and then translated to Spanish with the help of another student from IKIAM. The questionnaire was divided into five sections. The first section contained seven questions related to demographics. The specific age classes were chosen to be able to identify if there is a difference in observed effect between people who were there with the introduction of tilapias 20 years ago and who were not. People under the age of 30 could have been too young to observe an effect versus older people. The second section focused on the importance of ecosystem services and people's dependence on them and contained four questions. The third part contained six questions on the observed effect of tilapia farming on the ecosystem services. The fourth part, with one question, was related to the effect of specific management practices of tilapia farming

on ecosystem services. The last part contained four questions and was focused on current/future threats for tilapia farms and suggestions for the improvement of tilapia farming.

In total, 71 questionnaires were filled out throughout eight communities in ten days. These communities were Atacapi, Calvario, Lagarto Cocha, Las Palmas, Muyuna, Pano, San Jorge and Tiwintza. However, only 1 questionnaire was collected for the community Tiwintza and therefore this questionnaire was added to the community of Calvario as this community was very close-by to Tiwintza and had a similar distance to the river. The communities Atacapi, Muyuna and San Jorge were similar in size and bigger than the other communities. However, Atacapi is in a more rural area, whereas Muyuna and San Jorge are in urban areas. The communities Calvario, Lagarto Cocha, Las Palmas, Pano and Tiwintza are very similar in size, their rural location and distance to the city.
Within the communities, people above 30 were targeted and people who had been going to the river Tena or Pano for more than 20 years. This because they are more likely to have seen effects of tilapia farming than people who are younger or have not been going to the rivers for that long. The questionnaires were collected with the help of seven students from IKIAM. The communities with the corresponding number of questionnaires can be found in table 2.

Table 2: The communities where the questionnaires were collected, and the corresponding number of questionnaires collected in the communities

Community	**Number of questionnaires**
Atacapi	12
Calvario	10 (including 1 from Tiwintza)
Lagarto Cocha	9
Las Palmas	8
Muyuna	12
Pano	14
San Jorge	6

2.6.2 Analysis of the data from the questionnaire

When all paper questionnaires were collected, the data was entered into the online questionnaire in Qualtrics and all the written answers in Spanish were translated to English. Due to a relatively small sample size, a confidence level of 90% and an alpha of 10% were chosen.
Depending on the evidence needed to answer a research question and the kind of data, different methods of analysis were used. When an independent dichotomous or categorical variable was analysed with a dependent continuous variable, a one-way ANOVA was performed to determine if the independent variable impacted the outcome of the dependent variable. When two continuous variables were analysed, a correlation test (F-test) was performed to determine if more of variable A also meant more of variable B. For each research question, it will be explained which parts of the questionnaire were used and how they were analysed to answer the research question.

To understand the importance of the ecosystem services, only the ecosystem services identified through literature were used in the questionnaire. The ecosystem services identified during the questionnaire were not included in the analysis, as they were not incorporated into the questionnaire beforehand. To identify which ecosystem services are perceived to be most important to local communities, three parts of the questionnaire were used. These were the demographics, the nature service questions, and the external influence questions (Appendix C). In total, six different questions from these parts were used to answer the research question. A one-way ANOVA was used in the following cases, to test whether there were differences in means between:

- The community and the ranking of the ecosystem services
- The community and the dependence on ecosystem services

A correlation test (F-test) was used to identify:

- If a higher dependence on the ecosystem services also results in a higher ranking of those ecosystem services

To understand the observed effect of tilapia farming on the ecosystem services, again three parts of the questionnaire were used. These were the demographics, the nature service questions, and the external influence questions (Appendix C). In total, ten different questions from these parts were used to answer the research question. A one-way ANOVA was used in the following cases, to test whether there were differences in means between:

- The community and the observed effect of tilapia farming on the ecosystem services
- The age and the observed effect of tilapia farming on the ecosystem services
- The time in the community and the observed effect of tilapia farming on the ecosystem services
- Years going to the river and the observed effect of tilapia farming on the ecosystem services
- The importance of the river and the observed effect of tilapia farming on the ecosystem services
- The dependence on the river for their livelihood and the observed effect of tilapia farming on the ecosystem services
- The dependence of tilapia farming and the observed effect of tilapia farming on the ecosystem services

A correlation test (F-test) was used to identify:

- If a higher dependence on the ecosystem services also results in a more negative observed effect of tilapia farming on the ecosystem services

To understand the perceived contribution of tilapia farming practices to ecosystem service change and possible alternatives, four parts of the questionnaire were used. These were the demographics, the external influence questions, the drivers questions, and future management questions (Appendix C). In total, six different questions from these parts were used to answer the research question. A one-way ANOVA was used in the following cases, to test whether there were differences in means between:

- The community and the observed effect of the specific farming practices on the ecosystem services
- The dependence of tilapia farming and the observed effect of the specific farming practices on the ecosystem services

3.Results

3.1 Ecosystem services provided by the river Tena and Pano and their riverbanks

The literature review and questionnaire resulted in the identification of ten ecosystem services: four provisioning services, two regulating services, and four cultural services.

3.1.1 Provisioning services

The rivers Tena and Pano and their riverbanks provide four provisioning ecosystem services: the provisioning of fish for food, and water for human consumption, domestic use, and agriculture.

A common provisioning service in rivers is the **provisioning of fish for food.** Food provisioning refers to the capacity of an ecosystem to produce food resources, for example fish and wild-harvested foods that can be used for human consumption. In this study the focus is on the capacity of provision of fish for human consumption. From all freshwater fish in Ecuador, around 75% are concentrated in Amazonian freshwaters (Celi & Villamarin, 2020). Livelihoods of local communities depend on these Amazonian freshwaters and the Amazon rainforest (Santafe-Troncoso & Loring, 2021). This includes catching wild fish from nearby rivers. Wild fish that are caught by local communities in Napo include carachamas, nachi, ishingos and shikitu (Celi & Villamarin, 2020 ; Santafe-Troncoso & Loring, 2021). The wild fish are mostly consumed by the families themselves and incorporated in traditional dishes.

The results from the questionnaire have shown that besides the provisioning of fish for food, the rivers Tena and Pano also provide **water for human consumption** for the communities living close to the rivers. The water is also used for **domestic uses** such as cooking, bathing, and washing clothes. However, due to pollution from the discharge of waste and sewage from households in the city, the section of the rivers that merge and flow through Tena is not suitable for human use. As a result, the rural communities living west of the city mostly rely on the rivers for human consumption and domestic uses. In addition to water for consumption and domestic uses, the rivers are also utilized for **agriculture**, for the irrigation of crops (Appendix A: table 19). Some of the local crops grown in Tena are banana, cassava, beans, and maize (Tena Municipal Government, 2023).

3.1.2 Regulating services

The rivers Tena and Pano and their riverbanks provide two regulating ecosystem services: the regulation of the carbon cycle and flood control.

One regulating service is the **regulation of the carbon cycle**. Plants close to the river convert carbon dioxide from the atmosphere into organic carbon. When the plants decompose, the carbon goes back into the atmosphere. However, a part of the carbon from decomposed plant and soil material is washed into the river and then transported to sea. This process helps to reduce the amount of carbon that goes back to the atmosphere (WHOI, 2015).

Another regulating service provided by the river is **flood control and mitigation**. The rivers accommodate changes in water levels (Ganey & Spurrier, 2022). Vegetation in the river can buffer water levels through adjusting the vegetation cover. This is achieved through adapting the patterning of plant clumps to changes in discharge (Royal Netherlands Institute for Sea Research, 2020). This makes it into a natural buffer managing changes in water levels. Furthermore, vegetation on the riverbanks can slow the force of floodwaters and decrease peak flows for flooding (Brazos River Authority, 2018). In Tena, the river Tena flows through the centre of the city and many households surround it, as well as in the rural communities to the west of Tena that are in close proximity to the river Tena and Pano. Flood control and mitigation by rivers and riverbanks is therefore especially important in Tena.

3.1.3 Cultural services

The rivers Tena and Pano and their riverbanks provide four cultural ecosystem services: cultural identity, aesthetics, recreation, and tourism.

Cultural identity refers to the benefits ecosystems provide to support and maintain cultural practices, values, beliefs, and identities of a community. Research by (Santafe-Troncoso & Loring, 2021) has shown that eating native fish from the river is part of the culture of local communities in Napo. The local communities go to the river to fish the native fish and the study mentions that local communities have a connection to the river. The questionnaire has also shown local communities get a feeling of happiness and joy from the river.

Besides the river and riverbanks contributing to people's cultural identity, people can also appreciate it for its **aesthetics** (FAO d, 2022). Rivers and riverbanks can provide aesthetic enjoyment which comes from the appreciation people have for its natural features, for example the rapids and colours of the river or trees in the surrounding landscape (Parker & Oates, 2016).

Furthermore, rivers also function as a place for **recreation** and **tourism** (Böck, Polt, & Schülting, 2018) (FAO d, 2022). Recreation refers to activities that individuals engage in during their leisure time for personal enjoyment. It is often pursued locally, within one's community, and may not involve any significant travel or overnight stay. Tourism, on the other hand, involves travel and exploration of new places beyond one's usual surroundings and typically involves overnight stay. Tourism can contribute to income for local communities. An example of a recreational activity of rivers in Napo is sport fishing (Santafe-Troncoso & Loring, 2021). Other recreational activities that ecosystems offer are walking, swimming and meditation. Engaging in recreational activities can provide the opportunity for people to experience the benefits of the ecosystem services provided by the river directly (Daniel et al., 2012). An example of an activity related to tourism of freshwater ecosystems is river viewing for wildlife (MA, 2005).

3.2 Perceived importance of the provided ecosystem services

The previous chapter presented an overview of the ecosystem services provided by the river Tena and Pano and their riverbanks. This chapter explored the importance of these ecosystem services to the local communities. As the results were based on local communities' perspectives, this chapter started by providing an overview of the demographic characteristics of these communities.

3.2.1 Demographic characteristics

The first part of the questionnaire contained seven questions concerning the demographics of the respondents: gender, age, occupation, level of education, years lived in the community, ethnic background and years going to the river (Appendix C). In total, 71 questionnaires were conducted. A table summarizing the demographic characteristics can be found in Appendix B, demographics. The people questioned for the research were from 7 different communities: Atacapi, Calvario, Lagarto Cocha, Las Palmas, Muyuna, Pano and San Jorge (figure 2, Methods). The communities Atacapi, Calvario, Lagarto Cocha, Las Palmas and Pano were in rural areas of Tena, whereas Muyuna and San Jorge were in urban areas of the city. Out of the respondents, 42% was male and 58% was female (demographics, Appendix B). The biggest age group that filled in the questionnaire was between 30 and 40 years old, followed by 40 - 50 and 50 – 60 (figure 6a). The communities mostly consisted of people with an indigenous ethnic background as 76% of people questioned were indigenous and 24% Mestizo (figure 6b). The indigenous people identified as Amazonian Kichwa people, a grouping of indigenous Kichwa people and are known to have a strong connection to the nature. Mestizo refers to someone of mixed European and indigenous heritage. Around 49% had a high school degree as highest level of education, followed by 30% who had a bachelor's degree, 17% who had elementary school as the highest education and 4% who had a master's degree (figure 6c). Household chores, agriculture and teaching were the most common occupations of the people in the communities (figure 6d). The category "other" occupation consists of: public (6), retired (2), student (3), nurse (1), security guard (3), carpenter (1), services (1), police (2), commerce (1), vice-president of a community (1).

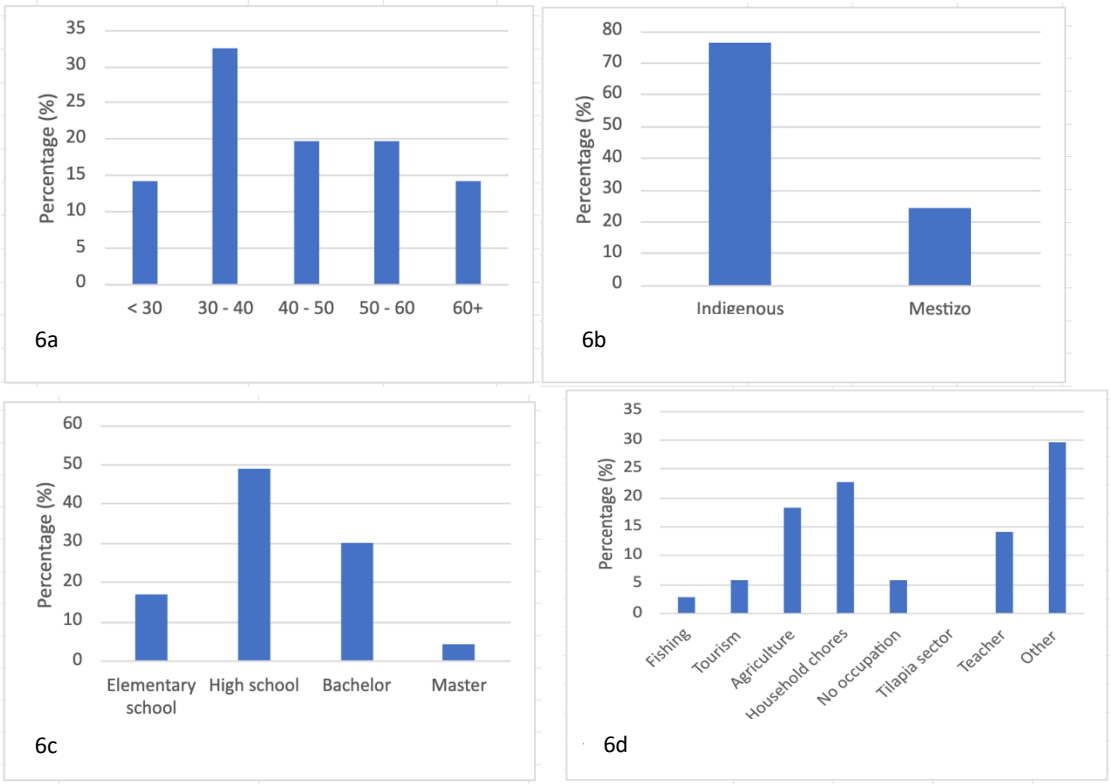

Figure 6: Demographic characteristics of the respondents. 6a: age, 6b: Ethnic background, 6c: Highest achieved education, 6d: Occupation

Around 45% of the questioned community members have lived in the community for more than 30 years (figure 7a), followed by 22% who have lived in the community for less than 11 years. Even though the community members might not have lived in the same community for a long time, 63% of the people questioned had been going to the river Tena or Pano for more than 30 years and 73% for 20 years or longer (figure 7b). It implied community members were still able to observe changes in the ecosystem services since the introduction of tilapia farming.

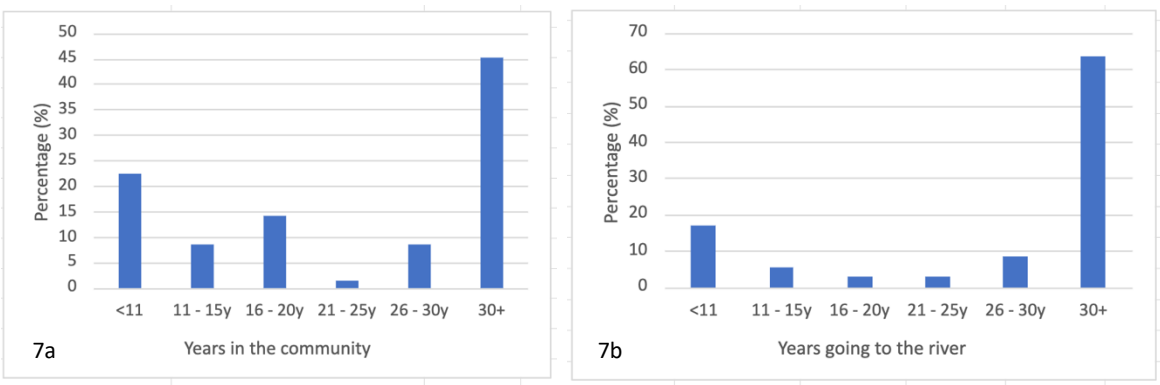

Figure 7: Demographic characteristics. 7a: Years lived in the community, 7b: Years going to the river Tena or Pano

3.2.2 Overview of the ranking and dependence on the ecosystem services

The rivers and riverbanks, and the ecosystem services they provide, are important to the local communities. Around 96% of people questioned said the rivers and riverbanks are important to them, and 86% of the people questioned said their livelihood depends on the river and riverbanks (figure 1 and 2, Appendix B). It shows that the rivers and riverbanks are an integral part of local communities' lives.

The ranking of the ecosystem services by local communities can be seen in table 3 below. There was a noticeable difference between the ecosystem service categories. The cultural services (tourism, cultural identity, and recreation) were ranked highest, followed by the provisioning service (providing food for people). One cultural service, aesthetics, was ranked below providing food for people. The last ranked services were the regulating services (flood control, regulation of the carbon cycle).

Table 3 : The ecosystem services ranked from most important (=1) to least important (=7). The lowest mean represents the highest ranked ecosystem service

Ecosystem service	Mean	Std Deviation
Tourism	2.57	1.73
Cultural identity	3.31	1.58
Recreation	3.32	1.69
Providing food for people	3.39	1.83
Aesthetics	4.15	1.65
Flood control	5.38	1.71
Regulation of the carbon cycle	5.96	1.37

The communities were also questioned on their dependence on the ecosystem services as communities might be dependent on services but not recognize their importance. In general, the local communities considered their wellbeing was dependent on all the ecosystem services as they were all ranked above 2 (figure 8). The communities considered their wellbeing was the most dependent on cultural identity, followed by recreation, tourism, aesthetics, regulation of the carbon cycle, providing food for people, and lastly flood control. Again, like for the ranking of the ecosystem services, the cultural services were ranked highest, followed by the regulating and provisioning services. The importance and dependence for tourism and recreation were strongly correlated, meaning that a higher dependence also resulted in a higher ranking of the service (table 5 and 6, Appendix B). For the other services there was no significant correlation between importance and dependence.

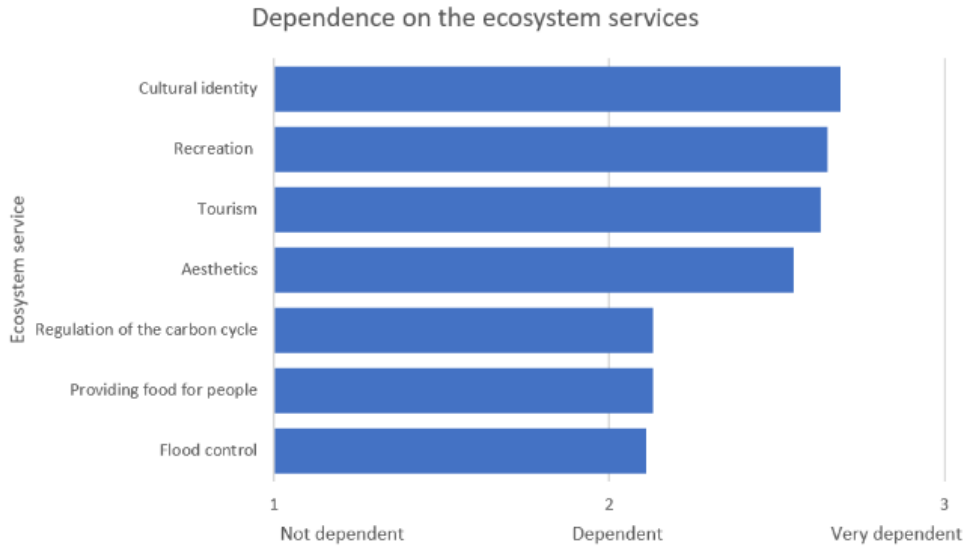

Figure 8: The dependence of local communities on the ecosystem services provided by the river and riverbanks of the river Tena and Pano

3.2.3 Provisioning services

The ecosystem service food provision for people was ranked on the fourth place in importance out of all the ecosystem services. Local communities eat fish from the river and mostly hunt for carachamas and viejas in the river, which are native fish. There was no significant difference in importance between the different communities.

Communities considered they were dependent on the provision of native fish by the river as it was part of their diet (figure 8). The communities generally did not consider they were very dependent on it as they also derived food products from numerous other sources in their surroundings like agriculture. However, when questioned on additional ecosystem services than the ones presented in the questionnaire, community members often referred to activities related to the domestic use of water: cooking, bathing, and washing (table 3, Appendix B). This suggests that the communities heavily rely on the river as a source of water for domestic purposes.
The dependence on the provision of food has influenced how important communities considered the ecosystem services. The more dependent someone said they were on the food provision, the higher they ranked the service in importance (table 1, Appendix B).

3.2.4 Regulating services

The regulating services were ranked lowest in importance by the local communities (table 3). Flood control was ranked fifth, followed by the lowest ranked ecosystem service: regulation of the carbon cycle.

There was no significant difference in importance of the regulation of the carbon cycle between the different communities. There was, however, a difference in importance of flood control between the different communities. Flood control was ranked as the least important ecosystem service by everyone in San Jorge (except for 1 person), whereas in Atacapi, the people ranked flood control higher (figure 3, Appendix B). This could have to do with the fact that San Jorge was in the south of the city Tena and further away from the river than the other communities. Therefore, people in the community might be less worried about the effect of floods and ranked flood control less high in importance.

Concerning the dependence on flood control and the regulation of the carbon cycle, communities considered they were dependent on both ecosystem services (figure 8). There was a significant difference between the communities and dependence on flood control and regulation of the carbon cycle. Communities Calvario and Lagarto Cocha both consider they are very dependent on the carbon regulation, whereas the other communities considered they are much less dependent on it (figure 4, Appendix B). People from Calvario expressed their high dependence on flood control as well, while people from San Jorge had mixed opinions varying between not dependent and dependent (figure 5, Appendix B). This could be, again, due to the fact that San Jorge was further away from the river and therefore less dependent on its flood control.
The dependence on flood control has influenced how important communities considered the ecosystem services. The more dependent someone said they were on flood control, the higher they ranked the service in importance (table 2, Appendix B).

3.2.5 Cultural services

The cultural services were ranked highest of all the services and people also considered they were the most dependent on cultural services for their wellbeing (table 3 & figure 8). This can be related to the fact that the majority of people questioned identified as Kichwa and therefore have a strong cultural connection with the river ecosystem. From all the ecosystem services, tourism was seen as the most important by local communities. After tourism, cultural identity was seen as the second most important ecosystem service. People have expressed that cultural identity is very related to the river for Kichwa people and that the river and riverbanks bring them feelings of happiness (table 3 and 4, Appendix B). The third-ranked ecosystem service was recreation. Swimming for enjoyment and cooling down was one of the main recreational activities that local communities take part in. Aesthetics was ranked fifth most important, below providing food for people.
There was a significant difference in importance of tourism and recreation between the different communities. The communities Calvario, Pano and San Jorge ranked tourism higher than the other communities (figure 6, Appendix B). It was difficult to find an explanation for this as Lagarto Cocha for example, which has similarities to Calvario, ranked tourism less highly. Recreation was ranked high by communities San Jorge, Lagarto Cocha and Las Palmas and less high by the other communities (figure 7, Appendix B). There was no clear difference between the rural communities and more urban communities.

Concerning the dependence on the cultural ecosystem services, the communities considered they were dependent to very dependent on them for their wellbeing. There was a significant difference between the communities and their dependence on tourism, recreation, and aesthetics. A big difference was observed between the communities and their dependence on tourism. In general, all communities considered they were either dependent or very dependent on it, except for people from Muyuna (figure 9).

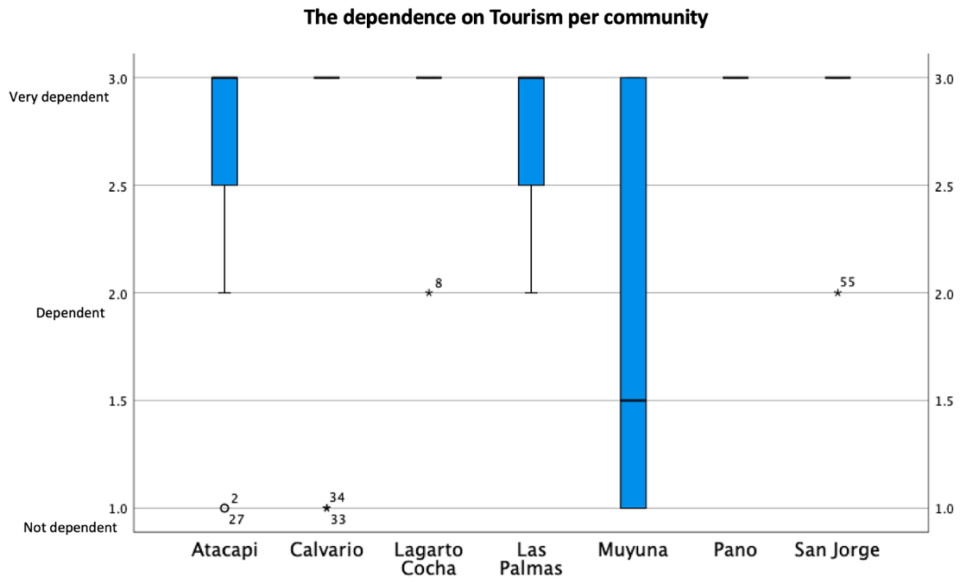

Figure 9: The dependence on tourism per community

The lower dependence on tourism by people in Muyuna was surprising as you would assume that urban communities depend more on tourism and aim more for tourism than communities further away from the city who focus more on income through agriculture. The people from Lagarto Cocha and Pano considered they were very dependent on recreation for their wellbeing, whereas this was less for Calvario, Muyuna and San Jorge (figure 8, Appendix B). The lower dependence for their wellbeing on recreation in San Jorge could be attributed to the fact that swimming and fishing in the river in the city is not possible due to pollution. Therefore the people in San Jorge might not incorporate it as much in their daily life and are less dependent on it for their wellbeing. Lastly, everyone in Lagarto Cocha said they were dependent on the aesthetics of the river ecosystem (figure 9, Appendix B). For other communities this varied much more between not dependent and very dependent.

There was a significant correlation between the dependence on tourism and recreation and the ranking of both ecosystem services in importance. The more dependent someone said they were on tourism and recreation, the higher they ranked the service in importance (table 5 and 6, Appendix B).

3.3 The effect of tilapia farming on Tena's river ecosystem services

In this chapter, the effect of tilapia farming on the previously discussed ecosystem services from the river ecosystems in Tena was explored, based on the perceptions of local communities living close to the rivers.

3.3.1 General overview of the observed effect on ecosystem services

Overall, tilapia farming had a negative effect on all ecosystem services (table 4). The biggest negative effect was observed for the provision of food for people (lowest mean). The least negative effect was observed for flood control (highest mean). However, it was still a negative effect. The mean indicated the extent of the observed impact of tilapia farming on the different ecosystem services. The lower the mean was below 3 (no effect), the bigger the negative observed effect. The higher the mean was above 3 (no effect), the bigger the positive observed effect. The standard deviation (SD) in table 4 showed the variability of the answers. The higher the standard deviation, the more spread out the answers were from the mean. For example, the SD for the provision of food for people was relatively low, indicating that the observed effects of tilapia farming on the provision of food were more consistent across the respondents. For the provision of food and aesthetics, with a mean observed effect of 1.62 and 1.73, and an SD of 0.91 and 0.93, the range of the observed effect was still negative. For the other services, the mean with the corresponding SD entails that positive effects of tilapia farming on the ecosystem services were also observed.

Table 4: The (observed) effect of tilapia farming on the ecosystem services provided by the river Tena and Pano. 1 = large negative effect, 2 = small negative effect, 3 = no effect, 4 = small positive effect, 5 = large positive effect.

Ecosystem service	Mean observed effect	Std Deviation	N
Providing food for people	1.62	0.91	71
Aesthetics	1.73	0.93	71
Recreation	2.04	1.33	71
Regulation of the carbon cycle	2.08	1.14	71
Tourism	2.21	1.45	71
Cultural identity	2.23	1.40	71
Flood control	2.34	0.93	71

The observed effect on the ecosystem services was influenced by various factors such as the surveyed community, the dependence on the river ecosystem, and other related factors. Notably, people from the community Lagarto Cocha observed more negative effects on the ecosystem services than the other communities. People from the community Muyuna generally observed a less negative effect on the ecosystem services than the other communities. This can be attributed to the fact that the community Lagarto Cocha was close to a commercial tilapia farm and therefore people in the community experienced more negative effects than communities further away from the farm. Furthermore, people that were more dependent on an ecosystem service, generally observed a more negative effect on this ecosystem service. The opposite was the case for the dependence on tilapia farming, where a higher dependence on tilapia farming would generally result in a more positive observed effect on the ecosystem service.

3.3.2 Providing food for people

Overall, tilapia farming had a negative effect on the provision of food for people. The range of the observed effect was between a large negative effect and a small negative effect so in general the observed effect was negative. From all ecosystem services, the biggest negative effect was observed for providing food for people. People pointed out how the farming had negatively affected other fish in the river (table 7, Appendix B). They observed a loss of native fish in the river. This loss was attributed to two things. Firstly, the contamination of water released from the tilapia farms into the river had negatively affected the fish in the river. Community members pointed out that the contamination of the farming water was caused by the feed given to the tilapias which contained hormones and high level of nutrients. Contamination of the water had also negatively affected the domestic use of water and water for consumption, according to local communities (table 7, Appendix B). As for the second reason of a loss in native fish, community members pointed out that tilapias were predators and ate the other fish which resulted in less native fish in the rivers when tilapias escaped from the farms into the nearby rivers.

Differences in the observed effect can be noticed across communities. In the communities Lagarto Cocha, Las Palmas, Pano and San Jorge, the biggest negative effect was observed with everyone (except for 3 people) observing tilapia farming has had a large negative effect on food provisioning. In Atacapi, Calvario and Muyuna a negative effect was also observed but it was less big than in the before-mentioned communities (figure 10, Appendix B).

3.3.3 Regulation of the carbon cycle

Generally, a negative effect of tilapia farming was observed on the regulation of the carbon cycle of the rivers and riverbanks. The range of the observed effect was between a large negative effect and no effect but in general the observed effect was negative. No specific examples of the effects were given by people questioned.

Differences in the observed effect can be noticed across communities. In the community Lagarto Cocha everyone observed that tilapia farming had a large negative effect on carbon regulation. In Atacapi, Las Palmas, Pano and San Jorge people also think tilapia farming had a negative effect on carbon regulation but less severe. In Calvario and Muyuna everyone (except for 4 people) observed tilapia farming had no effect on carbon regulation (figure 11, Appendix B).

3.3.4 Flood control

A small negative effect was observed from tilapia farming on the flood control of the river. The range of the observed effect was between a large negative effect and no effect but in general the observed effect was negative. From all the ecosystem services, the smallest negative effect was observed for flood control (table 4). The smallest observed effect could be related to the fact that no specific problems were observed over the years by the people in the communities. Between the communities there was no significant difference in the observed effect. There was, however, a significant difference between the number of years people have been going to the river and the observed effect. In the classes 11-15 years and 21-25 years, everyone observed tilapia farming has had a large negative effect on flood control. In the age classes <11 and 26-30 people also observed a negative effect of tilapia farming on flood control but it was less big. In the age class 16-20 everyone observed no effect of tilapia farming on flood control. For the age class 30+ people were less negative than the other communities and some people even observed a small positive effect of tilapia farming on flood control (figure 10). It shows that people who had been going to the river for longer and were there with the introduction of tilapia farming did not generally observe a more negative effect on flood control than the people who had been going to the river for less long.

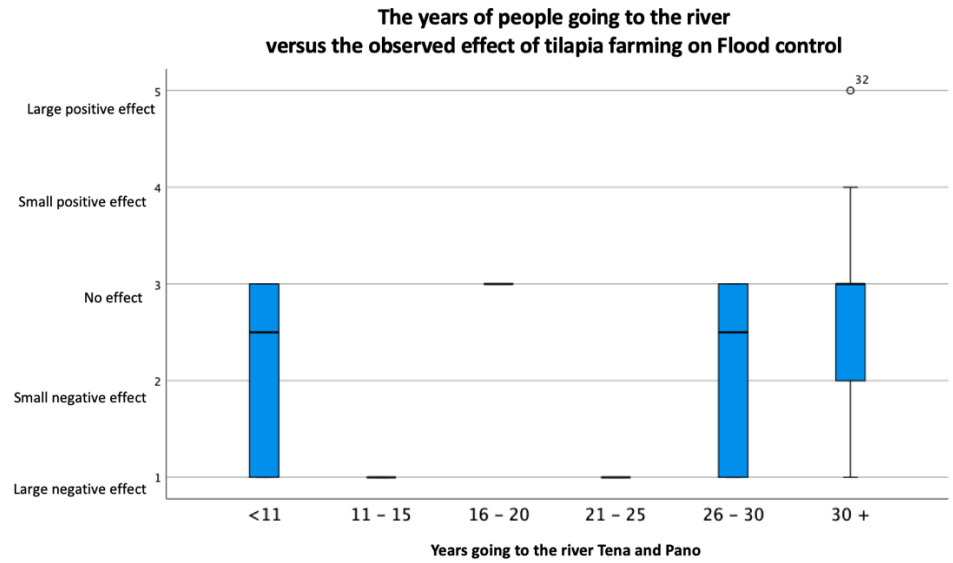

Figure 10: The (observed) effect of tilapia farming on flood control related to the number of years people have been going to the rivers and riverbanks for activities such as swimming or fishing.

3.3.5 Cultural identity

Tilapia farming has had a small negative effect on cultural identity. The range of the observed effect was between a large negative effect and a small positive effect but in general the observed effect was negative. Since the introduction of tilapia farming, people felt a loss in connection to the river and a loss in culture (table 7, Appendix B) (table 4, Appendix B). This was because they could not do certain activities related to the river anymore such as swimming and bathing for example due to contamination. Fishing and eating native fish also decreased due to the loss in native fish which used to be a part of their culture.

Across communities, there was a difference in the observed effect of tilapia farming on cultural identity. In Lagarto Cocha everyone (except for one person) observed a large negative effect of tilapia farming on cultural identity. In the communities Atacapi, Las Palmas, Pano and San Jorge people generally observed a negative effect as well, but it was less severe, and some people observed no effect of tilapia farming on cultural identity. In Muyuna this was also the case, with everyone (except for 2 people) observing tilapia farming had no effect on cultural identity. In Calvario people observed a more positive effect of tilapia farming on cultural identity (figure 12, Appendix B). One person mentioned that tilapias used to not be part of their culture but overtime it became part of their culture (table 4, Appendix B). The more positive observed effect by people could be related to their dependence on tilapia farming as people who were dependent on tilapia farming observed a less negative effect on cultural identity than people who were not dependent on tilapia farming (figure 11).

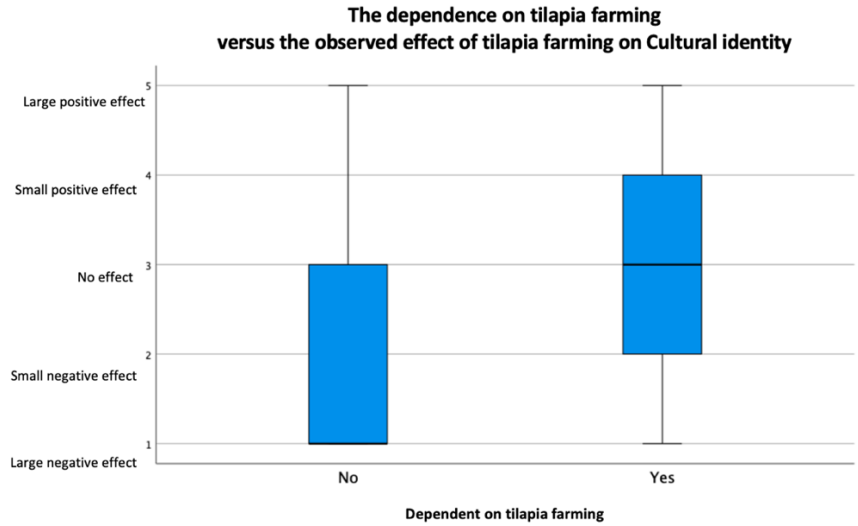

Figure 11: The (observed) effect of tilapia farming on cultural identity related to the dependence on tilapia farming

3.3.6 Aesthetics

A negative effect of tilapia farming on the aesthetics of the river ecosystem was observed. The range of the observed effect was between a large negative effect and no effect but in general the observed effect was negative. People mentioned murky waters in the river as a result of tilapia farming (table 7, Appendix B).

Differences in the observed effect were noticed across communities. In communities Lagarto Cocha and Pano everyone (except for 2 people) observed tilapia farming had a large negative effect on the aesthetics of the river. This could be due to the fact that there was a very big commercial tilapia farm next to the community Lagarto Cocha and that they have therefore observed a more negative effect. In Las Palmas the observed effect ranged between a large negative effect and a small negative effect. In Atacapi, Calvario and San Jorge the observed effect was a bit less negative with some people observing no effect on the aesthetics. In Muyuna, people were the least negative about the effect, with some people even observing a small positive effect of tilapia farming on the aesthetics (figure 13, Appendix B).

3.3.7 Recreation

Tilapia farming has also had a negative effect on recreation. The range of the observed effect was between a large negative effect and no effect but in general the observed effect was negative. Many of the effects on people's recreational activities were observed by the people in the communities. They mentioned they could not swim in the river anymore due to contamination by tilapia farms. People mentioned it caused health problems such as skin diseases (skin fungus), fungus on intimate parts (especially for women), lung infections, ear infections and children got sick from swimming in the river (table 7, Appendix B). Furthermore, they mentioned swimming in the river caused white spots on their skin (figure 12).

Figure 12: White spots on the skin of someone who participated in the questionnaire

For recreational activities such as sport fishing, people mentioned a loss of native fish in the river. Between the communities, there was a difference in the observed effect of tilapia farming on recreation. In communities Lagarto Cocha, Las Palmas, Pano and San Jorge everyone (except for 2 people) observed tilapia farming had a large negative effect on recreation. In the other communities, especially Atacapi and Muyuna, people thought less negatively about the effect of tilapia farming on recreation and some people even considered there was a positive effect of tilapia farming on recreation (figure 14, Appendix B). This more positive observed effect could be related to a few different factors, such as importance of the river and riverbanks, dependence on the river, dependence on tilapia farming and dependence on recreation itself. People who considered the river and riverbanks important observed tilapia farming had a much more negative effect on recreation than people who did not consider the river and riverbanks important as they considered that tilapia farming had a positive effect on recreation (figure 13).

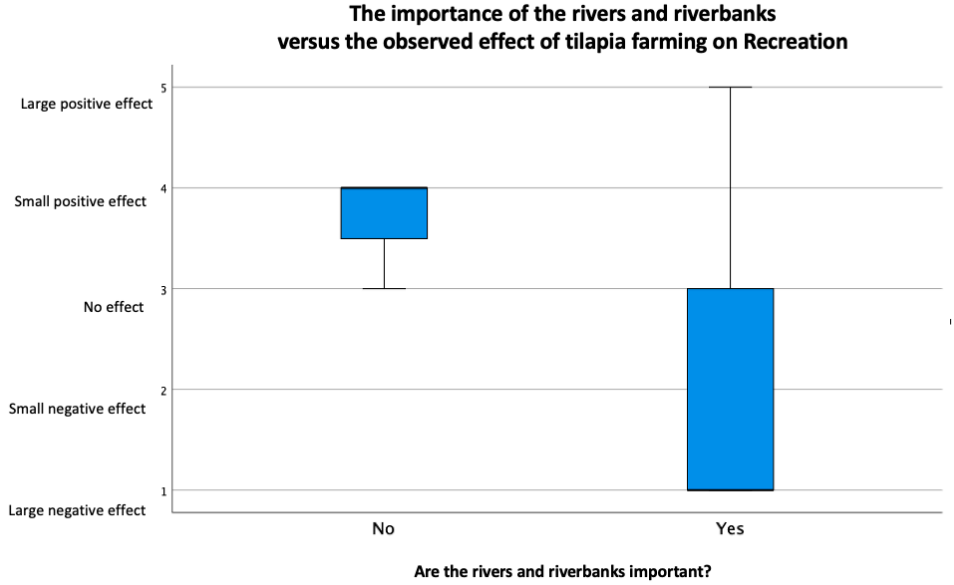

Figure 13: The (observed) effect of tilapia farming on recreation related to the importance of the river and riverbanks

Furthermore, people whose livelihood was dependent on the river and surrounding areas also observed a more negative effect on recreation than people whose livelihood was not dependent on the river and surrounding areas (figure 15, Appendix B). Dependence on tilapia farming and dependence on recreation also played a role in the observed effect as people who were dependent on tilapia farming observed fewer negative effects on recreation than people who were not dependent on tilapia farming (figure 16, Appendix B). As for the dependence on recreation, the analysis showed that the more dependent people said they were on recreation, the more negative effect they observed from tilapia farming on recreation (table 8, Appendix B).

3.3.8 Tourism

Lastly, tilapia farming had a negative effect on tourism provided by the river ecosystems. The range of the observed effect was between a large negative effect and a small positive effect but in general the observed effect was negative. Since the introduction of tilapia farming people observed less tourism, and some attributed it to contamination of the river from tilapia farming (table 4, Appendix B).

Differences in the observed effect were noticed across communities. In Communities Lagarto Cocha, Las Palmas and Pano everyone (except for 2 people) observed a large negative effect of tilapia farming on recreation. In Calvario and San Jorge people also thought tilapia farming had a negative effect on tourism but less severe than in the communities mentioned before. In Atacapi and Muyuna however, people observed a more positive effect than the other communities, especially in Muyuna where everyone (except for 4 people) thought tilapia farming has had a small positive effect on tourism (figure 17, Appendix B). This positive effect was especially observed by people who have spent 21 to 25 years in their community as everyone in this class observed tilapia farming had a large positive effect on tourism, whereas in other classes the observed effect was more spread out between a negative and positive effect (figure 18, Appendix B). People whose was dependent on the river and surrounding areas observed a more negative effect on tourism than people whose livelihood was not dependent on the river and surrounding areas (figure 14).

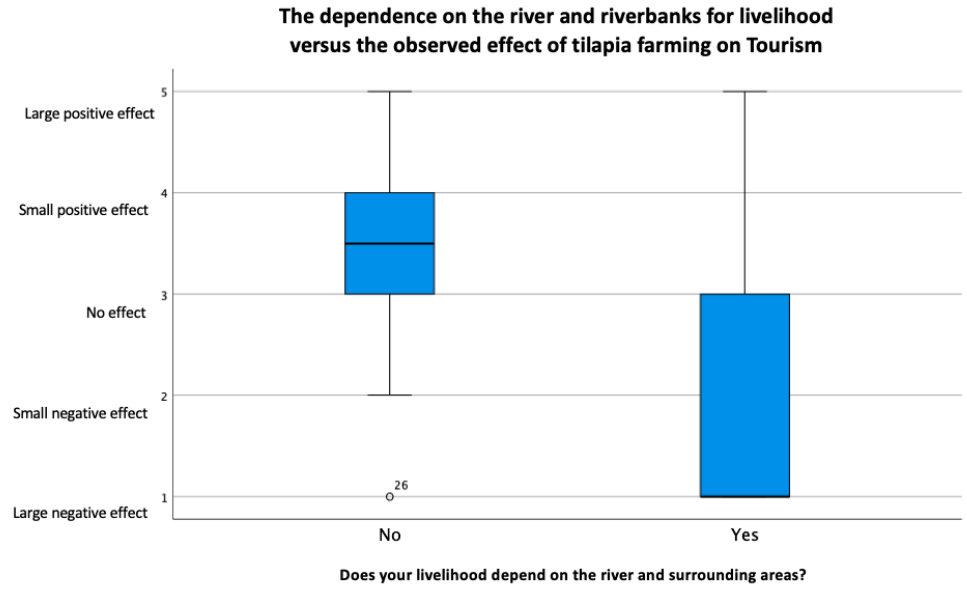

Figure 14: The (observed) effect of tilapia farming on tourism related to the dependence on the river and riverbanks for livelihood

The analysis also showed that the more dependent people said they were on tourism, the more negative effect they observed from tilapia farming on tourism (table 9, Appendix B).

3.4 The contribution of farming practices to ecosystem service change and possible alternatives

Previous chapters showed the importance of the ecosystem services provided by the river ecosystems in Tena and that these services have been negatively impacted by tilapia farming. This chapter looked into how the farming practices of tilapia farming contributed to changes in the ecosystem services and identified possible alternatives.

3.4.1 Farming practices and their contribution to ecosystem service change

In general, all farming practices had a negative contribution to ecosystem service change, according to local communities' perceptions, as all practices had a mean below 3 (table 5). A mean below 3 (no effect) meant the practice was seen to have a negative contribution the ecosystem service change. A mean above 3 meant the practice was viewed to have a positive contribution to ecosystem service change. There were many different elements to the process of tilapia farming. It was therefore important to see for each of these elements if and how much they contributed to the changes in ecosystem services and which elements were of the biggest concern. Details on each farming practice were provided based on five interviews conducted with tilapia farmers of commercial farms and farms for personal consumption (figure 15). The contribution of the practices to ecosystem service change were examined. Furthermore, differences in the effects of the practices were analysed between different communities. The locations of the interviews farms could be found in figure 4, Methods.

Table 5: The (observed) effect of the specific management practices of tilapia farming on the ecosystem services. 1 = large negative effect, 2 = small negative effect, 3 = no effect, 4 = small positive effect, 5 = large positive effect

Management practice	Mean observed effect	Std Deviation	N
Emptying the used water for farming into nearby streams	1.52	0.75	71
The "balanced" food that is given to the tilapias	1.68	1.02	71
The tilapias farmed close to streams and rivers	1.93	1.20	71
The number of tilapias farmed for commercial farming	1.97	1.22	71
The use of a non-native fish species for farming	2.08	1.26	71
Using rainwater or water from the river for the ponds	2.54	1.34	71
The number of tilapias farmed for personal consumption	2.76	1.31	71

The number of tilapias farmed for commercial farming

The size of the ponds for commercial purpose that were visited in Tena varied between a smaller pond of 4m x 9m x 1.6m and bigger ponds of 25m x 50m x 1m and 70m x 60m x 1.8m (Appendix A: A2.2, A3.2, A4.2). The number of tilapias grown varied between 500 and 25 000 per pond.


Figure 15: Two tilapia farms in Tena. A farm with commercial purposes on the left and a farm for personal consumption on the right

The number of tilapias farmed for commercial farming was seen by local communities to have a negative contribution to the ecosystem services (table 5). Communities believed it was not aesthetically pleasing since it took place of the natural vegetation of the riverbanks and the number of tilapias farmed could cause negative effects to the native fish when the tilapias escape into the river.

There was a difference between the communities and the observed effect of commercial farming on the ecosystem services. People from communities Lagarto Cocha, Las Palmas and Pano thought the number of tilapias farmed for commercial farming had a very negative effect on the ecosystem services. In Atacapi and Calvario, however, people had a more positive opinion (figure 16). This difference could be explained by the fact that there was a big commercial tilapia farm right next to the community Lagarto Cocha, which was close to Las Palmas and Pano. Therefore, they had experienced the effects of the commercial farm more than other communities questioned.

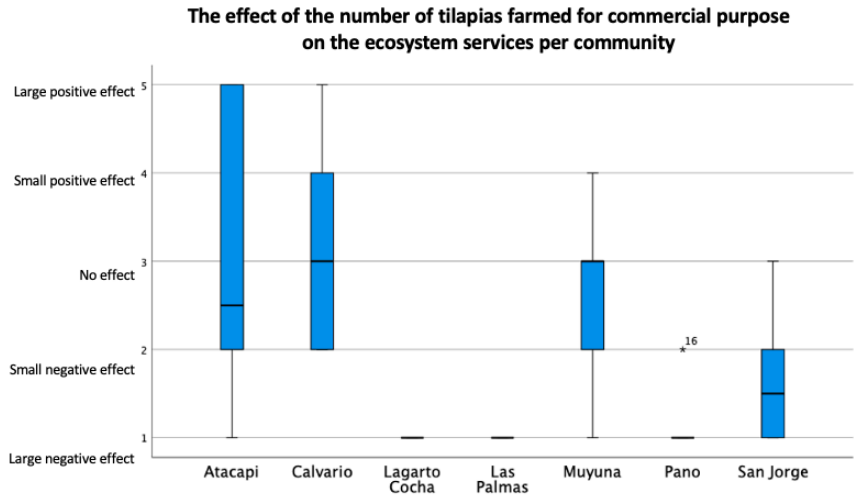

Figure 16: The perceived effect of the number of tilapias farmed for commercial farming on the ecosystem services per community

The number of tilapias farmed for personal consumption

The ponds for personal consumption were generally smaller than the commercial ponds and were often located in people's garden (figure 15). The ponds for personal consumption varied between 5m x 5m x 0.8m, containing 100 tilapias (and 100 carachamas) and a pond of 20m x 25m x 1m, containing 200 tilapias (Appendix A: A5.2, A6.2).

The number of tilapias farmed for personal consumption was viewed to have had the least negative effect on the ecosystem services. Opinions on the effect of the number of fish farmed for personal consumption were generally more positive than for commercial farming (table 5). Some people even mentioned that only allowing small farming for personal consumption could be the solution to the problems experienced from tilapia farming (table 10, Appendix B). Community members believed that the effects on native fish and contamination of the river would be much smaller.
There were differences in the observed effect of farming for personal consumption and the communities. In Lagarto Cocha, Pano and San Jorge the answers varied between a large negative effect and no effect. In Atacapi, Calvario, Las Palmas and Muyuna there were people who thought it could also have a small positive or large positive effect on the ecosystem services (figure 19, Appendix B). The positive effect that people talked about mostly related to a positive effect on cultural identity as people saw tilapia as part of their culture now (table 4, Appendix B).

The tilapias farmed close to the streams and rivers
The tilapia farms differed in distance to the rivers Tena, Pano and Misahualli. The tilapia farms that were visited in Tena differed between 4m and 150m in distance to the rivers. However, four of the five farms visited were within 11 meters of the river or a branch of the river.
Farming so close to the river was viewed to contribute negatively to the ecosystem services (table 5) and could lead to problems. When the water in the river flooded, the tilapias inside the ponds ended up in the river, affecting the native species. The closer the farms were to the river, the higher the chance they got flooded when the river floods and therefore also a higher chance that tilapias escaped into the river. When inside the river, tilapias could eat native fish and compete with native fish for food. Farming close to the river therefore had a negative effect on the provision of food (native fish) from the river.
Communities perceived the effects of farming close to the river differently. The communities Lagarto Cocha, Las Palmas and Pano perceived this as having a very negative effect on the ecosystem services and perceived it more negatively than other communities (figure 20, Appendix B). The difference could again be linked back to the commercial farm next to Lagarto Cocha as the farm was only 7 metres away from the river (A3.2, Appendix A).

The "balanced" food that is given to the tilapias
The tilapias were raised with different kinds of "balanceado". Balanceado was the food given to the tilapias, which contained a lot of nutrients and hormones for growth. The average time required to raise tilapias until fully grown was 6 months. However, farmers mentioned that with the use of hormones in the food it was possible to reach the tilapias full grown size and weight much faster, in 4 months (Appendix A: A2.2).
Community members perceived the balanced feed as a negative practise and related the contamination of the river to the use of balanceado for the tilapias (table 7, Appendix B). It was perceived to have a negative effect on the fish in the river, as well as recreation, tourism, and aesthetics because people believed it caused eutrophication which caused algal blooms and changed the aesthetics of the river (table 10, Appendix B).
Four communities (Lagarto Cocha, Las Palmas, Pano and San Jorge) shared the same perception on the effect of the food for tilapias. The four communities thought it had a very negative effect on the ecosystem services. For communities Calvario and Muyuna, the perceived effect varied between very negative and no effect. In Atacapi it varied between very negative and very positive, with a more negative average effect (figure 21, Appendix B).

Using rainwater or water from the river for the ponds
The farms were located close to the river or a branch of the river. This was because the tilapia farmers utilised the water from the natural river flows close to the house for their ponds. During the farming,

the water from the ponds was exchanged with clean water sometimes to enhance the growth of the tilapias (Appendix A: A2.2).

Using rainwater or water from the river for the ponds was perceived to have a small negative effect on the ecosystem services by the local communities (table 5). No specific argumentation was given on why the community members perceived a negative effect.
There was a difference between the communities on the perceived effect of rainwater or river water use. Lagarto Cocha perceived the use of rainwater or water from the river for farming as very negative to negative, Pano mostly perceived it as negative with some people perceiving it as having no effect and in Muyuna it was mostly perceived as having no effect. In Las Palmas and San Jorge it varied between a large negative effect and a small positive effect. Atacapi and Calvario perceived it as mostly positive (figure 22, Appendix B).

Emptying the used water for farming into nearby streams
During and after farming, the dirty water was released back into the nearby rivers (Appendix A: A2.2, A3.2, A5.2, A6.2). Most farmers did not apply a cleaning process to the water.
Community members thought that emptying the used water for farming into nearby streams had the biggest negative effect on the ecosystem services (table 5). Many of the community members pointed out the contamination of the river due to the release of wastewater from tilapia farms into the river. People mentioned that the river could not be used when the water from the tilapia farms was released into the river. It had a negative effect on the native fish in the river through contamination and therefore provision of food for people by the river, as well as recreation and tourism.
All communities agreed on the fact that emptying the used water into nearby rivers did not have any positive effects on the ecosystem services. The perceived effects by Lagarto Cocha, Pano and San Jorge were very negative. In Atacapi and Las Palmas, the perceived effect was between a large negative effect and small negative effect, so generally negative. In Calvario and Muyuna, people generally perceived the practice had a negative contribution to ecosystem service change. However, some people believed that there was no effect of emptying the used water into nearby streams on the ecosystem services (figure 23, Appendix B).

The use of non-native fish species for farming
As mentioned in the introduction, tilapia was not native to Ecuador but had been introduced in farming due to its affordability, fast-growing rates of the species, easy adaptation, and high levels of proteins.
The use of a non-native fish species in the farming was perceived to have a small negative effect on the ecosystem services by the local communities (table 5). It was mentioned tilapias are predators and therefore ate the other fish in the river (table 7, Appendix B). It therefore had a negative effect on provision of native fish from the river. Consequently, it influenced recreation and people's cultural identity as eating dishes with native fish and fishing for native fish used to be a part of their culture but now was becoming less possible.
There were significant differences between the communities on the observed effect of the use of non-native fish in farming. The practice was considered to have a large negative effect by communities Lagarto Cocha and Pano, followed by San Jorge for which the perceived effects differed between a large negative effect and no effect. People from Muyuna thought the use of a non-native fish species had no effect on the ecosystem services and for the communities Atacapi, Calvario and Las Palmas the perceived effects varied between a large negative effect and a large positive effect (figure 24, Appendix B). The perceived positive effect can be explained by the fact many people did not know tilapia was a non-native species. When told that the species is from Africa, people were surprised and said that whilst it might not have been part of their culture before, it was considered as part of their culture now (table 4, Appendix B).

Overall, people from the communities Lagarto Cocha and Pano had the most negative perceptions about all the farming practices, while people from Atacapi and Calvario had the least negative perceptions. The difference could be attributed to the presence of a large commercial tilapia farm close to Lagarto Cocha and Pano and people from the communities therefore experienced more negative effects from the farming than other communities. As a result of experiencing more negative effects from tilapia farming, people from Lagarto Cocha and Pano also had more negative perceptions of the farming practices used.

Besides differences between communities, there was also a noticeable difference in the observed effect of management practices on ecosystem services between people that were dependent on tilapia farming and people that were not. For all management practices, except for the use of non-native fish, a more positive effect was observed by people who were dependent on tilapia farming than by people who were not (figure 25 till 30, Appendix B). People who were dependent on tilapia farming were more biased on the effects of it on the ecosystem services.

3.4.2 Possible alternatives for the farming practices of tilapia farming

As mentioned before, emptying the used water from farming into nearby streams, and the food given to tilapias were perceived to have the biggest negative impact on the ecosystem services. Both practices were related to the contamination of the river. The contamination was related to the loss of native fish in the river, which was the ecosystem service that people observed the most negative effect on from tilapia farming. The contamination was also related to the loss of tourism, the ecosystem service that was perceived most important by local communities. Through alternative farming practices the negative impact on ecosystem services could be decreased. Unfortunately, around 65% of the community members said not enough financial and institutional support was given from the government and implementing the alternative practices was therefore difficult (figure 31, Appendix B).

Wastewater treatment

In the questionnaire people were asked to provide suggestions that could improve tilapia farming. The majority of the suggestions provided were related to treatment of the wastewater from the tilapia farms (table 10, Appendix B). This was seen as a possible solution to counteract the contamination of the river caused by the release of dirty farming water into the river.

Alternative food

Another suggested solution was to substitute the food of tilapias by native food from the area such as yuca, cassava leaf or Chinese potato (table 10, Appendix B). The use of natural food could again have decreased the contamination of the river as the high amount of nutrients from the current food were perceived to lead to eutrophication and pollute the river when the dirty farming water was emptied into the river.

Farming further from the river

Community members also proposed the relocation of the ponds to a further distance from both the river and nearby communities (table 10, Appendix B). The exact distance was not suggested. More distance in between the ponds and the river would have decreased the chance of tilapias escaping their ponds when the river floods. Consequently, when fewer tilapias escaped into the rivers it would have had less effect on the native species in the river as the tilapias would not have eaten the native species and competed for food.

Socializing the problem & governmental support

In addition to proposing implementable solutions, socialization of the problem was also suggested (table 10, Appendix B). Socialization of the problem entailed bringing together all relevant parties,

including the government, farmers, and local community members to discuss the problem together. By sharing their experiences and ideas related to tilapia farming, community members could contribute valuable insights, while all parties could work together to identify what solutions could be implemented. Furthermore, education and guidance from the government on sustainable farming could have helped in minimizing the negative impacts of tilapia farming. Community members mentioned that governmental support, whether it is financial or educational, was necessary to solve the problems related to tilapia farming. Due to financial constraints, many farmers were unable to implement wastewater treatment measures, and therefore, financial support from the government could have helped.

4. Discussion

In this chapter, the perceptions of local communities are compared to results found in literature and limitations of this research are discussed.

4.1 Comparison of the results with literature

The results of my research show that the cultural services provided by the river Tena and Pano and their riverbanks are valued most among local communities, followed by the provisioning services, and regulating services. Local communities believe tilapia farming has a negative effect on all the ecosystem provided and observe the biggest negative effect on the provision of food for people, followed by aesthetics, recreation, regulation of the carbon cycle, tourism, cultural identity, and flood control. All current farming practices contribute negatively to ecosystem services change, according to local communities. The most detrimental practices to ecosystem service change are the discharge of the used farming water into nearby streams and the use of balanced food for tilapias. Both practices cause contamination and eutrophication of the river, which negatively impact ecosystem services such as the fish in the river, recreation, tourism, and the aesthetics through algal blooms. Alternative farming practices include wastewater treatment before its release into the rivers and the use of native food from the area.

Perceived importance of the ecosystem services

The results from my second research question on the perceived importance of the ecosystem services show that tourism, cultural identity, and recreation are the three highest ranked ecosystem services in terms of importance by local communities. These three services are all cultural services. However, in general, provisioning services are the primary source of livelihood for many people, especially for those in rural communities and are therefore often perceived most important (Booi, Mishi & Andersen, 2022). This difference can be explained by the fact that almost 80% of people questioned were indigenous and considered themselves Kichwa. Kichwa people are known to have a strong cultural connection with the river which explains the high ranking of cultural identity among the ecosystem services (Santafe-Troncoso & Loring, 2021). Furthermore, Tena is part of the Chakra route, a tourist route through Tena and the Amazon which focuses on getting income for communities through cacao farming and tourism, especially focused on Kichwa communities (Santafe-Troncoso & Loring, 2020). Tourism is therefore an important ecosystem service for local communities in Tena. The ranking of the services can also be related to the dependence of local communities on the three highest ranked ecosystem services as the communities consider they are also the most dependent on the same three ecosystem services.

The regulating services flood control and regulation of the carbon cycle were ranked lowest in my research. Research by (Aguado et al., 2018) has shown that people from urban areas place more value on regulating services than people from rural areas. This matches with the results of my research.

The beforementioned comparisons with literature show that the importance of ecosystem services to local communities can vary in different areas. There are similarities with other studies, such as the low ranking of regulating services but also unexpected differences like the high ranking of cultural services. It is therefore crucial to conduct case-specific research to determine the importance of ecosystem services for each study. When it is known what ecosystem services are important to local communities and which services they depend on, management can be adapted to this to ensure the welfare of local communities (Lau et al., 2019).

Observed effect in ecosystem services since the introduction of tilapia farming

The findings of my research show that overall, the communities observe a negative effect from tilapia farming on all ecosystem services. Other studies into the environmental impacts of fish culture, like shrimp farming, also found negative effects on the environment such as water contamination, eutrophication and spread of diseases (Páez-Osuna, 2001). The adverse impacts on the environment can, in turn, affect the provision of ecosystem services considering the cascade framework.

The introduction of non-native species is regarded as the second most significant threat to biodiversity, after habitat alteration and degradation (Erarto & Getahun, 2020). Non-native species becoming invasive can threaten health through the introduction of diseases and negatively impact native species by fighting for the same resources as native species, taking over their habitat and eating the native species (Saba et al., 2021). Eventually, invasive species can cause the disappearance of the native species altogether (Mooney & Cleland, 2001). The communities in Tena observed the biggest negative effect of tilapia farming on the provision of food for people and mention the loss of native fish relates partly to the escaped tilapias eating other fish in the river. Different studies that have looked into the effect of tilapias on native fish species and biodiversity have found that tilapias are highly invasive, with the unintended release of tilapias posing a threat to the survival of native fish species (Canonico et al., 2005) (Martin & Valentine, 2010). They have been observed preying on the eggs of other fish and competing for food, which further increases the negative effects on the local ecosystem (Martin & Valentine, 2010). This explains why people from the communities in Tena observe fewer native fish since the introduction of tilapia farming and an increase of tilapias in the rivers. The replacement of the native fish by tilapias can decrease water transparency, increase the abundance of microalgae, and change native community structure in the river affecting the balance of the ecosystem (Erarto & Getahun, 2020). An ecological assessment of the food web in Tena's river should be conducted to validate the communities' observations.

The communities observe the second biggest negative effect on the aesthetics of the river. The community members mention murky waters as an effect on the aesthetics, as a result of wastewater discharge into the river. Research shows that discharge of wastewater from fish farms can result in pollution and lead to cloudy water, most likely due to eutrophication from nutrient enrichment into the river (Newman et al., 2005) (Goldburg & Triplett, 1997). In addition to noticing the cloudiness of the water, members of the communities believe that the tilapia ponds are less beautiful than the riverbanks. Similarly, (Outeiro, Villasante & Oyarzo, 2018) has also researched people's perception on the appearance of fish farms, next to the coast in Chile. The majority showed that fish farms on the Chilean coast was perceived as spoiling the beauty of the landscape. Moreover, 55% of people are less likely to visit places in Chile where fish farms are sited.

The pollution and decreasing aesthetics of the river can also explain the observed decline of recreation and tourism in Tena. The negative effect on the aesthetics can discourage tourism as the river is less appealing for river viewing for wildlife for example. Due to pollution of the river, people are less likely to swim in the river for recreation and mention getting sick. Different fish pathogens can infect humans and cause diseases, which can enter the body through the mouth or skin (Goldburg & Triplett, 1997). I could not find literature relating fish farming to the specific white spots on the skin that community members relate to tilapia farming. This suggests that the white sports may be caused by factors other than tilapia farming. To further investigate the potential effects of balanced feed and wastewater discharge, it is essential to collect water samples from the tilapia ponds, the river water near the tilapia farms, and the water located further away from the farms.

The previously made comparisons between my research and the literature show that the perceptions of the local communities in Tena match with outcomes that would be expected if the ecosystem service changes would have been monitored on site. My research therefore shows that the

perceptions of local communities offer valuable indications regarding the effect of tilapia farming on Tena's river ecosystem services and its local communities.

Perceived contribution of tilapia farming practices to ecosystem change and possible alternatives
All current management practices of tilapia farming in Tena are seen as contributions to the decrease in the included ecosystem services by local communities. Other studies showed that if aquaculture is not managed properly it can have negative effects on the environment and therefore also on the ecosystem services (Martin & Valentine, 2010).

Emptying the used water for farming into nearby streams is thought to have the biggest negative effect, followed by the balanced feed for tilapias. People from the communities relate both practices to contamination and eutrophication of the river resulting in negative effects on people and native fish. The balanced feed that tilapias receive contains high amounts of nutrients and hormones to promote growth. The nutrients from the fish feed are excreted into the water of the ponds and afterwards released into the river. A study into the effects of shrimp farming found that the discharge of wastewater from shrimp ponds into nearby waterbodies can lead to water quality deterioration (Páez-Osuna, 2001). The release of the nutrients from fish excretion into the water can pollute water bodies, lead to eutrophication and can be harmful to humans (Streicher & Reiss, 2021) (Goldburg & Triplett, 1997). Nutrient enrichment leading to eutrophication can be a risk to aquatic ecosystems and can lead to a decrease in ecosystem services (Streicher & Reiss, 2021). The consequences of eutrophication include deoxygenation and the death of fish in the river (Newman et al., 2005).
Different alternative farming practices were suggested by local communities to minimize the negative impacts of tilapia farming. The most commonly suggested approach was wastewater treatment of the ponds before the release into the rivers. Researchers conducted studies to evaluate the efficiency of different plant species in removal of pollutants in tilapia farming effluents. The plants had different nitrogen and phosphorus removal capacity. Based on the findings, the use of floating aquatic plants (*Ceratophyllum* demersum) was identified as the most efficient and cost-effective method of wastewater treatment because of high growth rates and easier maintenance (Beheary et al., 2019). The pollution removal from plants was also higher than artificial removal. (Iber & Kasan, 2021) researched the use of plants, specifically algae, for the treatment of shrimp effluent water and shows the use of ponds with algae are highly efficient for the removal of nutrients from the wastewater.

Another suggestion from community members to counteract contamination from tilapia farming was to substitute the feed by natural food and food from the region such as yuca, cassava leaf or Chinese potato. (Poot-López, Gasca-Leyva & Olvera-Novoa, 2012) researched the effect of replacing part of the balanced feed of tilapias with Chaya leaves (tree spinach). The research shows that when 50% of the balanced food is replaced with Chaya leaves there is no difference in the growth of the tilapias. Replacing part of the food contributes to less use of balanced feed and can lead to a decrease in phosphorus pollution in rivers (Goldburg & Triplett, 1997). (Páez-Osuna, 2001) did an experiment in which the excretion of shrimps from artificial food was compared to excretion from a natural diet. The results showed a significantly lower nitrogenous excretion from the natural diet and therefore had less adverse impacts on water quality. The use of natural food can also work well for farms in rural areas where effluent from the farming ponds could be used to irrigate the crops nearby (Poot-López, Gasca-Leyva & Olvera-Novoa, 2012). This could make the process more sustainable and minimize contamination of the river. The suggestion from the community members seems like a viable option to counteract contamination. Therefore, further research should be conducted into all of the foods that can replace the balanced feed without decreasing the yield.

4.2 Limitations

The previous section has highlighted that the communities' perspectives were a good indication of the effects of tilapia farming on river ecosystems and the farming practices contributing to these effects. The results also provide insights into how local communities rank the importance of ecosystem services. Both results can be used to adapt management practices to ensure the welfare of local communities and ecosystem health. Despite the strengths of my research, my study also presents limitations. This section provides an overview of those limitations, starting with the limitations of identifying the ecosystem services. Then, the limitations related to the identification of management practices are discussed and lastly, the limitations related to the questionnaire.

Limitations related to the identification and importance of ecosystem services

The ecosystem services were identified through literature research and updated after conducting a questionnaire with the local population. Since the questions concerning ecosystem services in the questionnaire were based on the ecosystem services identified through literature research, the ones identified through the questionnaire were not included. For example, water for consumption was not identified through literature research and therefore not included in the question related to the dependence on ecosystem services. However, when asked what other benefits they receive from the river and riverbanks people from the communities mentioned water for consumption and their dependence on it. This may impact the findings of my research as other ecosystem services that are important to local communities have not been included in the questionnaire and my analysis. However, besides a few other ecosystem services mentioned, people in the communities seemed to agree with the importance of the chosen services through literature research. By not including all the possible ecosystem services, the questionnaire was more concise and comprehensive for the local communities. This meant a higher number of questionnaires conducted, enabling my research to provide a good overview of the effect of tilapia farming on Tena's ecosystem services and local communities and the causes of this effect. Furthermore, the research still gives a good impression on how important the river and riverbanks are to local communities because in general the communities were dependent on all ecosystem services chosen. If time allows, future research should include more ecosystem services that were not covered in this study to gain a broader view of the services important to local communities.

The use of complex terminology related to the ecosystem services in the questionnaire is another limitation. For example, the use of the term "carbon regulation". The term may not have been familiar to the local communities, and as a result, they may not have understood what was meant by it. The lack of understanding could have made it difficult for them to rank it and may have resulted in the service being ranked lower than it actually was in terms of importance. Efforts were made to explain the concept to them so it is possible that the communities were able to understand the term after it was explained to them. Additionally, the research was conducted with a large number of participants so even though some of the participants might have not understood, the overall outcomes are still representative. Future research should use more accessible language to ensure that all ecosystem services are fully understood by the local communities.

Limitations related to identification of management practices

The identification of management practices was done through semi-structured interviews. Since there was limited time and students who could help conducting the interviews, only five semi-structured interviews were conducted which has resulted in a generalized identification of the management practices. Although it may have led to a generalized overview, almost every farming practice was the same between the interviewed farms so it has still given a representative view of the farming practices.

The interview questions were first written in English and then translated to Spanish which could have resulted in nuances being lost in translation. This also applied to the transcription of the interviews as the interviews were recorded in Spanish and had to be translated back to English. Additionally, as I lacked the required proficiency in Spanish to conduct the interview, a fellow student was responsible for conducting the interviews. This meant I was not able to ask follow-up questions to answers given by the interviewees and had to trust the student to formulate the questions correctly. Although the answers from the interviews might not have been as detailed as possible it has not changed the main findings as the management practices were still identified. If time allows, future research should follow the entire process of tilapia farming for a few months alongside different farmers to observe all the details of the process.

Limitations related to the questionnaire

I collaborated with students of IKIAM on the questionnaire formulation. The goal was to conduct as many questionnaires as possible to gain a representative sample of the population. To achieve this goal I simplified terminology related to ecosystem services and questions to make it more concise, comprehensible, and easier to translate to Spanish. However, this meant less explanation of the questions was given and resulted in a more simplified questionnaire. For example, the question where people have to indicate how dependent they are on the ecosystem services does not clarify what is meant with "dependent". Therefore, people could have interpreted the question differently and answer a different level of dependence based on that. Also some open questions were not entirely answered the way I intended to. The question concerning specific problems observed by people was sometimes answered very shortly with for example "contamination" even though I would have benefited from more in-depth answers concerning which farming practice they related this problem to for example. Since the question was simplified and only asked for problems related to tilapia farming, I often did not receive this information. Besides the use of more simplified language, it is likely that nuances have been lost in the translation from English to Spanish. Even though the use of simplified questions and the translations might have led to less detailed or accurate answers, the results from the questionnaire have given a good general overview of the effect of tilapia farming Tena's river ecosystem services and the farming practices responsible for this effect. For future research it would be good to do workshops and in-depth interviews with the local communities to gain a deeper understanding of the problems related to tilapia farming.

Besides limitations related to the formulation of questions, the sample size was relatively small, with just three more respondents than required which could lead to a decreased reliability of the results. The results of the questionnaire therefore likely sketch a less clear picture of the communities and their perception on tilapia farming. Even though a larger sample size might give more precision, my sample size was big enough to give a general overview and highlight differences between communities. For future research I would recommend taking more than two weeks for conducting the questionnaires in order to get a bigger sample size and more precise results.

4.3 Implications for environmental management and policy

The results of this study are timely and relevant, given the increasing concerns over the negative impact of aquaculture on the environment and the need for sustainable practices in aquaculture (Godoy et al., 2022). As highlighted by (Aguirre et al., 2021), Ecuador's Constitution "advocates for the conservation of ecosystems and biodiversity, the prevention of environmental contamination, the recovery of degraded natural spaces, the sustainable management of natural resources and the establishment of a national system of protected areas to maintain biodiversity and ecosystem services". The constitution "indicates that the government shall protect the right of the people to live in an ecologically healthy environment and will guarantee the preservation of nature. Furthermore, the protection of water sources and riverbanks is mandated by the Water Law (Celi & Villamarin, 2020).

However, laws are frequently unenforced which underlines the need for research that identifies and addresses the negative effects of aquaculture on local communities and ecosystems (Aguirre et al., 2021). This study provides valuable insights into the detrimental impacts of tilapia farming and suggest alternative management practices that could minimize these effects. The findings of this study can inform policy makers in adapting their policies and regulations that promote sustainable tilapia farming practices. By providing alternative management practices that minimize the negative impacts of tilapia farming, policymakers can better enforce existing laws and regulations with the goal of achieving sustainable tilapia farming practices that support both the ecosystem health and well-being of local communities.

5. Conclusion

In this chapter, each research question will be answered separately, before answering the main research question. The chapter ends with recommendations to improve tilapia farming to minimize the negative effects on the ecosystem services and communities.

RQ1: What are the ecosystem services provided by the river Tena and Pano and their riverbanks?
Both rivers and their riverbanks provide a variety of provisioning, regulating, and cultural ecosystem services. The provisioning services include: the provisioning of fish for food, water for consumption, domestic use of water and water for agriculture. The regulating services include: the regulation of the carbon cycle and flood control. The cultural services include: cultural identity, aesthetics, recreation, and tourism.

RQ2: Which ecosystem services are perceived to be the most important to Tena's local communities?
Tena's rivers and riverbanks are important to the local communities and an integral part of the communities' lives. The livelihoods of the majority of the local communities depend on the rivers and riverbanks. The cultural services are the most important to local communities and the communities are also the most dependent on them for their wellbeing, largely due to the indigenous background of the local communities. The regulating services are the least important to the local communities. The ecosystem service tourism is considered most important to local communities, followed by cultural identity, recreation, food provision, aesthetics, flood control and carbon regulation. In general, the communities are dependent on all ecosystem services.

RQ3: What is the observed effect of tilapia farming on the ecosystem services provided by the river Tena and Pano and their riverbanks?
Tilapia farming has a negative effect on all ecosystem services, according to local communities' perceptions. Tilapia farming has the biggest negative effect on food provisioning, followed by aesthetics, recreation, regulation of the carbon cycle, tourism, cultural identity, and flood control. For food provisioning, community members observe a loss of native fish due to contamination from tilapia farming and tilapias eating the native fish in the river. Regarding the aesthetics of the river ecosystem, tilapia farming is causing waters to become murky, which is having a negative effect on the river's appearance. Recreational activities like swimming in the river are causing health problems such as skin diseases and people getting sick due to contamination from the tilapia farms. As a result, people are refraining from partaking in these activities. For another recreational activity, sport fishing, people observe a loss of native fish in the river. As for cultural identity, the decrease in daily activities related to the river, including swimming, fishing, and eating native fish result in a loss of connection to the river. This loss of connection and decline in cultural practices is leading to a loss in culture and therefore cultural identity. Since the introduction of tilapia farming, people are also observing a decrease in tourism. Additionally, while no specific examples are given, community members observe a general decrease in regulation of the carbon cycle and flood control due to tilapia farming as well. Communities close to the tilapia farms experience more negative effects than communities further away from the farms.

RQ4: What is the contribution of tilapia farming practices to ecosystem service change and what are possible alternatives?
All current management practices of tilapia farming negatively affect the ecosystem services of Tena's rivers and riverbanks, according to local communities' perceptions. The most adverse impact on the ecosystem services is caused by the discharge of wastewater from farming into nearby streams, followed closely by the food given to the tilapias. Both practices contribute to river contamination. The distance of farms to the river has the third most negative impact on the ecosystem services because it results in tilapias escaping into the river when the river floods, affecting native species. The

subsequent management practices in decreasing order of effect are: the number of tilapias farmed for commercial purposes, the use of non-native species, and the use of rainwater or river water for the ponds. Farming for personal consumption has the least negative effect on the ecosystem services, much less than the effect of commercial farming. Solutions to counteract the negative effects of tilapia farming on the ecosystem services are wastewater treatment, alternative feed for tilapias, farming further from the river, socialization of the problem and governmental support.

Main research question: What is the effect of tilapia farming on Tena's river ecosystem services and local communities and what is causing this effect according to local communities?

In conclusion, tilapia farming has a negative effect on Tena's river ecosystem services and its local communities due to the inadequate management of tilapia farming. The most adverse impacts on the ecosystem services are caused by wastewater discharge of the tilapia ponds into the river and the tilapia feed. Both are causing river contamination resulting in a decrease in native fish species, recreational activities, and connection to the river. Farming of tilapia, a non-native species, close to the river is causing the escape of tilapias into the river during floods, further contributes to the decrease in native fish species. Through its current farming practices, tilapia farming is causing a decrease in all ecosystem services provided by Tena's rivers and riverbanks. Local communities living close to the river are dependent on these ecosystem services and are therefore suffering the consequences of these practices. Thus, there is a need for better farming practices to mitigate the adverse effects of tilapia farming on Tena's river ecosystem and its local communities.

Recommendations

From the results of my research I recommend an ecological assessment of the river's food web and collecting water samples close to the tilapia farms, as well as further away. I also recommend the mapping of the tilapia farms as current data on the number of farms and their location is missing. The ecological assessment, water samples and mapping will provide more detail on the effects of tilapia farming and determine the magnitude of the problem. In the meantime, the ponds should be contained or moved further from the river, when possible, to minimize the risk of tilapias escaping during floods of the river. In addition, part of the balanced food for the tilapias should be replaced by natural food from the surroundings, like Chaya leaves. Further research should determine which other foods can substitute the balanced food without decreasing the yield. Furthermore, I recommend investigating the production of native fish species and promoting the use of these species in aquaculture by the government.

To ensure tilapia farming does not have negative impacts on river ecosystem services and local communities, it is crucial to foster collaborations between all parties involved, including the local communities, government, and fish farmers. I strongly recommend a gathering of all parties involved to exchange knowledge, share experiences, and promote better practices for tilapia farming. Improving tilapia farming can contribute to recovering the river ecosystems and its ecosystem services in Tena and can extend to other areas. Given the special relationship between the river ecosystem and the well-being of local communities, such improvements can provide the local communities with a more stable and sustainable source of livelihood.

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Appendix A: Interviews

This appendix contains the interviews conducted with tilapia farmers. The interviews were done in Spanish and recorded. The recordings were transcribed in Spanish through the programme "Sonix". However, with transcribing, sentences can get altered so with the help of Spanish-speaking students the Spanish recordings were summarized in English.
The questions asked to the tilapia farmers, both in English and Spanish can be found below.

A1. Interview questions

Introduction

I'm doing research for my master thesis into tilapia farming. Is it ok if I record the answers so that I can write them down later? And is it ok if I take some pictures?

Estoy investigando para mi tesis de maestría sobre el cultivo de tilapia. ¿Está bien si grabo las respuestas para poder escribirlas después? ¿Y está bien si tomo algunas fotos?

Questions

English: Do you farm for your own consumption or for profit? If it is for profit, for how much do you sell them?
Spanish: ¿Cultiva para su propio consumo o para obtener beneficios? Si es con fines lucrativos, ¿a qué precio los vende?

English: how many tilapias do you farm?
Spanish: Cuantas tilapias cree que tiene?

English: How big are the ponds? Volume?
Spanish: ¿Que dimensiones tiene la piscina?

English: What is the process of tilapia farming? From the babies to the adults. How old are they when they are sold/eaten?
Spanish: Puede contarme un poco del proceso de crianza de tilapias? ¿Si compran alevines y los crían? ¿Cuánto tiempo toman las tilapias en estar listar?

English: Where do you take the water from for the pools?
Spanish: ¿De dónde proviene el agua usualmente?

English: How far from the river are the ponds?
Spanish: A cuanto del rio se encuentan las piscinas?

English: What are the tilapias being fed? Is the food different when they are young than when they are old? Where do they get the food?
Spanish: Que usan para elimentar las tilapias? ¿Es lo mismo para las tilapias pequeñas y grandes? ¿Dónde compran la comida?

English: What happens to the dirty water of the ponds? Is it released back into the river?
Spanish: Luego que se hace con el agua de las tilapias?

Thank you for your time, we appreciate it!
Gracias por su tiempo, se lo agradecemos.

A2. Commercial pond 1

This interview was conducted on the 22nd of November 2022. The interviewers were Gabriel Criollo and Iris Jonker. The interviewee was Carlos. The coordinates of the tilapia farm and location of the interview are: -0.9574244370674949, -77.80956574189909.

A2.1 Transcription interview commercial pond 1

Speaker1: [00:00:01] Ok, a ver. ¿La primera pregunta cultiva para su propio consumo para obtener beneficios Si es con fines lucrativos, a qué precio los vende?
Speaker2: [00:00:12] Empezando desde ahí. Soy empleado. Es para la venta para el comercio.
Speaker1: [00:00:23] ¿Cuántas tilapias en promedio cultiva?
Speaker2: [00:00:25] Más o menos. Ahorita como no hay mucha, mucho mercado, estamos más o menos con unas se ponen más o menos unas 500 por cosa que no se tiene como la rotación. Si usted llega, es esa un ejemplo. Les vota a mil, 2000, no por 1500, porque siempre hacemos cambios de agua para que la tilapia salga de una mejor calidad.
Speaker1: [00:00:50] ¿Una pregunta cuántas cosas tienen aquí?
Speaker2: [00:00:53] Más o menos dos. Cuatro, ocho, 12. Unos 20, 30, 20, 20 pasos.
Speaker1: [00:01:06] ¿Qué tamaño en promedio tienen los estanques?
Speaker2: [00:01:09] Sí, son más o menos unas piezas de 25 por 50 de largo.
Speaker1: [00:01:16] ¿Las de aquí son para los alevines, No es cierto? Estas chiquitas.
Speaker2: [00:01:19] ¿No? Esto es para los ornamentales. Ornamentales. ¿Ornamentales? Esto no tiene nada que ver con lo que estila.
Speaker1: [00:01:28] Ya se. ¿Cuál es el proceso de cría de la tilapia, desde las crías hasta los adultos? ¿Qué edad tienen cuando se venden o consumen?
Speaker2: [00:01:39] La tilapia normalmente sale a los siete meses, seis, siete meses al día, normalmente, naturalmente, sin hormonas, sin nada que le saca los siete meses, 7 6 7 meses.
Speaker1: [00:01:56] ¿Las piscinas tienen algún tipo de aclimatación?
Speaker2: [00:01:59] No, es todo natural.
Speaker1: [00:02:03] ¿A qué distancia del río están los estanques?
Speaker2: [00:02:06] Está más o menos a una distancia de unos 150 metros del río
Speaker1: [00:02:13] ¿Cómo se alimentan las tilapias? La comida es diferente cuando son comestibles que cuando son mayores. ¿De dónde sacan la comida?
Speaker2: [00:02:21] Normalmente nosotros compramos un balanceado. Solo con balanceado. Les cuidamos prácticamente lo que alimentamos.
Speaker1: [00:02:29] ¿Y qué ocurre con el agua sucia de los estanques? Se devuelven al río.
Speaker2: [00:02:34] ¿Y se devuelven al río?

Speaker1: [00:02:35] Buena pregunta. Y de la alimentación más o menos. ¿Cuánto usan por pozo?
Speaker2: [00:02:41] Toca hacer el cálculo, la cantidad de peces que esté por pozo, esa se le hace el cálculo.
Speaker1: [00:02:48] Y los alevines los tiran contabilizando los alevines. Claro.
Speaker2: [00:02:52] Porque nosotros aquí normalmente utilizamos solo el macho, porque todo hacemos manual. Claro, no utilizamos hormonas para utilizarle, la hembra y el macho solo utilizamos la hembra, digamos el macho.
Speaker1: [00:03:05] Pues es como que meten 5500 tilapias y después esas crecen, la sacan y de ahí otras 500.
Speaker2: [00:03:13] Ayayay, listo. Por eso lo digo. Es un sistema de rotativa.
Speaker1: [00:03:17] Claro, yo.

A2.2 English summary commercial pond 1

Nr of tilapias: 500 per pond, 2000 in total at the end (because 4 ponds)
Nr of ponds: 4 (but used to use 20/30 ponds but not anymore because there is too much competition to farm tilapia)
Reason: Commercial
Food: Balanceado
Size of the pool: 25 * 50 * 1(?)
Process:

- Buy the babies
- Raise it with different kind of balanceado

Time required to grow them: 6 to 7 months
Water source: from the river
Kind of balanceado:

- Babies: growing up balanceado
- Young: fattening balanceado
- Then a mix of both

What happens with the dirty water: back into the river
Distance to the river: 150 meters

Other comments:

- Exchanging the water from the ponds with clean water when the tilapia are growing up to improve the growth of the tilapias
- Used to use 20/30 ponds but not anymore because there is too much competition to farm tilapia)
- When you use hormones in the food they grow until adult in 4 months (much faster) but when it doesn't have hormones it takes 6 to 7 months
- His ponds are 150m from the river
- Only males in the ponds

A3. Commercial pond 2

This interview was conducted on the 26th of November 2022. The interviewers were William Quezada and Iris Jonker. The interviewee did not want to share his name. The coordinates of the tilapia farm and location of the interview are: -1.025067, -77.887366.

A3.1 Transcription interview commercial pond 2

Speaker1: [00:00:12] Bien. No creo que nos da una idea. Vas a ver a Ya, ya. Ok. Entonces nos gustaría saber, por favor. Las tilapias en general son para consumo propio o para vender.
Speaker2: [00:00:26] Aquí es para comerse para la venta más que.
Speaker1: [00:00:28] Todo.
Speaker2: [00:00:29] Por lo que. Pienso que la gente sí tiene también las casas así, pero más pequeñas, con.
Speaker1: [00:00:38] Perdón.
Speaker2: [00:00:39] Para el comercio más.
Speaker1: [00:00:40] Que todo. ¿Y una pregunta bastante final, ¿no? ¿Y más o menos usted estima o se trabaja en una piscina? ¿De qué?
Speaker2: [00:00:47] Si yo trabajo aquí.
Speaker1: [00:00:48] ¿Y más o menos cuántas tilapias cree que albergan una piscina? ¿Y cuántas habrá?
Speaker2: [00:00:53] A veces depende por decir. En esa piscina que más o menos le mandamos unos 25.000. ¿Depende, ¿no? Porque de.
Speaker1: [00:01:00] 25.000 ya.
Speaker2: [00:01:02] Depende del tamaño de la piscina y la profundidad también. Más o menos se le manda A6A7 alevines por metro cuadrado, más.
Speaker1: [00:01:09] O menos seis a siete alevines por metro cuadrado de.
Speaker2: [00:01:12] Límite más o menos. Está claro que le mandan más también veces cuando hay buen oxígeno y bueno, pero más o menos es de.
Speaker1: [00:01:19] 6 a 7 normal por metro cuadrado por metro cuadrado. ¿Hay otra pregunta y entonces más o menos si son seis o siete por metro cuadrado, más o menos, cuántos? ¿Qué dimensiones tiene esta piscina? Normalmente, digamos.
Speaker2: [00:01:31] Esta de aquí más o menos no le calculamos, pero nosotros siempre le hemos sembrado 25.000 aquí.
Speaker1: [00:01:38] Porque más o menos.
Speaker2: [00:01:39] Si le midieron antes. Me recuerda el inicio por qué.
Speaker1: [00:01:42] Sí.
Speaker2: [00:01:42] Para poderle coger el cálculo.
Speaker1: [00:01:44] De cuánto más o menos desde aquí, unos 70, acá unos 60, no.
Speaker2: [00:01:47] Algo así es.
Speaker1: [00:01:48] 70 por 50 aproximadamente. Y de profundidad más o menos.
Speaker2: [00:01:52] De profundidad no es muy la parte por decir es medio así, en la parte no está. ¿La tabla siempre es más hondo, de ahí para qué será? Esa tabla tiene unos tres metros. Debe tener.
Speaker1: [00:02:04] Tres metros.
Speaker2: [00:02:05] Dos metros a tener esa parte, la más alta de ahí arriba, unos 40 50 centímetros.

Speaker1: [00:02:10] Bien, a 40 hay ahí. Entonces más o menos de tres. Iba bajando hasta 40 centímetros. Ah, ya, ya, ya. Oiga, una pregunta. ¿Y entonces cómo es el proceso? ¿Cómo es el proceso de las tilapias? ¿Usted compra alevines y les crían? ¿Qué pasa?
Speaker2: [00:02:25] Un ejemplo aquí como es también tienen la producción de alevines, entonces nosotros los compramos aquí mismo, ellos vienen, les siembran un ejemplo abajo, primeramente, las cosechan lo que es las piscinas de reproducción de hoy los recogen y los clasifican más o menos. No solo los que pasan en la clasificadora se quedan y les dan una hormona, así como para la reversión y pueden reproducirse unos 28 días, le dan los 28 días y ahí si están a la venta. Entonces ahí sí nosotros compramos ya, ya, luego nosotros más o menos aquí les sembramos más o menos al mes le hacemos un recambio más o menos de algo así como que desinfectarlo y volverlo a llenar. Y cada mes más, que todo se lo hacen, pero cuando son pequeños, más que todo la alimentación y. Y eso más que todo.
Speaker1: [00:03:21] ¿Y una pregunta cuánto tiempo más o menos toma la tela? ¿Tiene que estar preparada para para la venta? Claro.
Speaker2: [00:03:27] Más o menos unos seis meses. Le calculamos desde que llega a donde nosotros.
Speaker1: [00:03:30] Ya unos seis meses. Ya, ya y perfecto entonces. ¿Ya, pero son las piscinas, son enormes, ¿no? Entonces el agua donde viene la bolita que para las tilapias.
Speaker2: [00:03:42] Tiene una entrada como de aquí a la otra finca, tiene una entrada del río así
Speaker1: [00:03:46] Ah, y entonces traen el río de por allá y va bajando así.
Speaker2: [00:03:50] El agua fría. Si hay una entrada, no más agua fría, de ahí la dividen, así como ella también como son de agua caliente, entonces de vez en cuando se utiliza agua fría y de ahí solo la propia agua. De aquí se pueden usar todas las demás
Speaker1: [00:04:02] Así ya para alimentar las tilapias como hacen la comida, compran que les dan aquí mismo, plantas, hojas
Speaker2: [00:04:10] Balanceado más que todo aquí desde pequeños, balanceado por decir el balanceado que siempre se ha consumido. Así de ese balanceado más que todo nosotros le damos cuando somos pequeños, por decir unas cuatro o cinco veces al día, ya dividido desde las ocho hasta las cuatro o cinco. Ya mientras van creciendo va reduciendo, digamos cuatro veces, tres veces hasta dos veces ya cuando van de salida.
Speaker1: [00:04:35] Pero y cambia el balanceado según el año, la edad de los ovinos.
Speaker2: [00:04:41] Y aquí cuando nosotros llegan los alevines, a veces llegan pequeños, nosotros tenemos que darle un balanceado número 450 que es polvito ya unos días y de ahí antes no había, ahora hay una balanceada nutra que se llama de la marca nutra que ya viene como para ya no moler, que antes se les había moler, el 380 lo molían, pero ahora ya llegó un nueva nutra esto ya viene. Después va pasando un mes más o menos, se le va eso de ahí a la pepita más grande, otro mes y otra toma de diferentes tamaños. Depende de la edad, también.
Speaker1: [00:05:12] Hay.
Speaker2: [00:05:13] Ciclos de crecimiento. Así pues.
Speaker1: [00:05:16] Primero le ponen el crecimiento, el polvito y luego van cambiando el de engorde más grande, más grande, más grande. Hasta los seis meses
Speaker2: [00:05:22] Más o menos están los cuatro, le damos crecimiento a cuatro o cinco, por ahí aceleraba el engorde y ya el 280.
Speaker1: [00:05:29] Ya.

Speaker2: [00:05:30] Entonces ese ya es como ya para prepararlos para la salida.
Speaker1: [00:05:33] Ah, ya. Y una pregunta más, tú me comentabas que por ejemplo bueno, ya viene la beta, están un mes aquí y más o menos cada mes se hace una limpieza y es agua. ¿Qué pasa con la agüita después?
Speaker2: [00:05:45] Nosotros un ejemplo de aquí sale el nosotros le bajamos, le ponemos una malla para que no se salgan y toda esa agua va para abajo. Ahí ya se desecha. Porque en realidad.
Speaker1: [00:05:57] Creo.
Speaker2: [00:05:58] Que hay un. Aquí hay un tipo. ¿Cómo se llamaría? Un. Un tipo donde se recogen.
Speaker1: [00:06:06] Todas las aguas.
Speaker2: [00:06:07] Y de ahí empieza. Llega un nivel y empieza a desfogar para abajo. Hay un tipo como medio filtro y de ahí a vuelta abajo.
Speaker1: [00:06:14] Y entonces como que recibe un tratamiento pequeñito, va filtrando y así va poquito a poquito.
Speaker2: [00:06:18] Sí, porque en realidad yo desde que llegué aquí ya había eso, no hay. La segunda pequeña filtración no es más o menos del agua, de ahí baja así igual se desemboca al río, igual más abajo y me.
Speaker1: [00:06:30] Voy a mi amiguísimo. ¡Qué chévere! Muchas gracias muchísimo. No, no, chévere, chévere allá chévere. Muchas gracias por.

A3.2 English summary commercial pond 2

Expert in tilapia farming
Nr of tilapias: 25000, 7 tilapia per square meter
Nr of ponds: 5?
Reason: Commercial
Food: Balanceado, depending on the age (baby food is like dust and the food for older tilapia's is bigger)
Size of the pool: 70 * 60 * 1.8 (deeper areas)
Process:

- Buy the babies
- Raise it with different kind of balanceado

Time required to grow them: 6 months
Water source: Natural river flow (Pano river)
Kind of balanceado:

- Babies: growing up balanceado
- Young: fattening balanceado

What happens with the dirty water: goes back into the river pano, no cleaning process
Distance to the river: 7m from the river

Other comments:

- Other people farm tilapia just for producing the babies to sell the babies

A4. Commercial pond 3

This interview was conducted on the 26th of November 2022. The interviewers were William Quezada and Iris Jonker. The interviewee was German Albuja. The coordinates of the tilapia farm and location of the interview are: -0.9621295149773229, -77.85669961710262.

A4.1 Transcription interview commercial pond 3

Speaker1: [00:00:00] Ya. Entonces solamente preguntas básicas. Nada. Nada en especial. Ok, amigo. Entonces la pregunta es. La primera pregunta es. Dice ella. ¿El cultivo que tenían la tercera para su consumo, para los vecinos, para los amigos o para vender? Para la venta. Para la venta, principalmente. Muy bien. Entonces. ¿No consumían ustedes?
Speaker2: [00:00:23] Poco a poco, sí. Pero la mayor parte fue para la venta.
Speaker1: [00:00:27] Fue para la venta y tenían aquí. Y esto es más o menos. ¿Cuántas creen que tenían ustedes en números?
Speaker2: [00:00:33] Y unas alevines se pusieron 1200 alevines
Speaker1: [00:00:37] 1200 alevines.
Speaker2: [00:00:38] Ya de ahí con el proceso se desarrollan y terminan efectivamente 800 tilapias del promedio que salen.
Speaker1: [00:00:48] El resto mueren de.
Speaker2: [00:00:50] Mortandad, se comen entre ellas, se van por las crecientes y todo.
Speaker1: [00:00:54] El tiempo se van por las crecientes.
Speaker2: [00:00:55] Pájaros, que son los amigos que dan cacería cuando son pequeños ya. Entonces todo eso está considerado.
Speaker1: [00:01:04] ¿Interesante ya más o menos de ustedes, cuántas dimensiones cree que tiene la piscina? ¿De cuánto? ¿Por cuánto es la cosa?
Speaker2: [00:01:10] Tiene cuatro por nueve, cuatro por
Speaker1: [00:01:13] Nueve metros y de profundidad más o.
Speaker2: [00:01:14] Menos. Ya tienes unos 60 metros.
Speaker1: [00:01:16] Unos 60 aproximadamente. No, ya. Please down. Perfecto. Entonces usted compra los alevines.
Speaker2: [00:01:26] Nosotros los adquirimos.
Speaker1: [00:01:28] Ya. ¿Y de ahí cómo hace para que crezcan? ¿Les damos un balanceado diferente o un cuidado especial?
Speaker2: [00:01:33] El balanceado viene por etapas de desarrollo.
Speaker1: [00:01:37] Ya.
Speaker2: [00:01:38] Eso ya está generalizado. Entonces cuando son muy pequeños es un polvo. Luego comienza ya a crecer y el balanceado es mucho más grandecito. Y después ya viene la etapa final, que es la de engorde y desarrollo. Cuando ya la pepa del alevín es más grande porque ya las tilapias están aproximadamente de una libra y media, que es lo que sale al mercado
Speaker1: [00:02:03] Bien a libra y media. Unos tremendos animales no tanto, son gorditas ya. ¿Otra pregunta más entonces más o menos usted cuánto tiempo cree que lo estima de la tilapia para que crezca a su tiempo aproximado?
Speaker2: [00:02:17] ¿Que es rentable? Son seis meses
Speaker1: [00:02:19] Seis meses.
Speaker2: [00:02:20] Pasados los seis meses comienza a hacer pérdida.

Speaker1: [00:02:22] Claro, se los comen, comen, comen, comen y no hay chiste. Ya. Perfecto. Vaya. Entonces, otra pregunta interesante. ¿De dónde viene el agua que usted usa para o usaba para las tilapias?
Speaker2: [00:02:34] Nosotros tenemos en la parte alta dos ojos de agua. Sea dos
Speaker1: [00:02:38] Vertientes. Claro.
Speaker2: [00:02:40] Entonces esto viene por el canal y abastece aquí directamente.
Speaker1: [00:02:45] Ya, perfecto, muy bien allá. Entonces me decía que usted, usted tenía diferentes formas para crear tilapia desde chiquitas grandes que va cambiando de balanceado.
Speaker2: [00:02:54] Va llegando compras los alevines que son los más pequeños, y luego comienza la fase de desarrollo hasta los seis.
Speaker1: [00:03:01] Meses ya interesantes, seis meses chao.
Speaker2: [00:03:04] Y se vuelve.
Speaker1: [00:03:05] Otra pregunta más. ¿Y el agüita?
Speaker2: [00:03:08] El agua cumple un proceso ya al mes aproximadamente se hace una fase de desinfección, luego a los tres meses y finalmente al 5.º mes se vuelve a hacer una desinfección del agua.
Speaker1: [00:03:23] Y eso afecta a las tilapias.
Speaker2: [00:03:24] La poza cuando está en este estado, por ejemplo, tiene que entrar a una etapa de mantenimiento, de desinfección y luego se procede al llenado y ya está, recién salió a la producción, entonces está para limpiar, desinfectar y volver a cargarlo.
Speaker1: [00:03:41] ¿Oiga, y eso lo limita a las tilapias? No, no, para nada. Ya, es.
Speaker2: [00:03:45] Que depende de lo que uses.
Speaker1: [00:03:47] Ah, ya, ya, perfecto, ya. ¿Qué más queremos? A ver, dice. Oye, eso nada más, amigo, nada más. Muchísimas gracias por la información, la verdad muy valiosa. Perdón, amigo, es un hombrecito. Germán Albufera, Germán Albufera. Muchas gracias, don Germán. Gracias otra vez. William Quezada de la familia Quezada. De repente yo creo que he escuchado mucho eso. Hija, familia, no hijos de William Quezada.
Speaker2: [00:04:08] Es algo que debes de considerar en tu estudio. Es que la tilapia no crece así porque sí. La tilapia también tiene un proceso negativo en el desarrollo, ya que la tilapia es muy sensible y se atrofia y no crece, se atrofia por lo general cuando sufre algún chubasco, algún impacto, algo ya no se desarrolla normalmente, entonces ya no sacas a los seis meses en la tilapia libre y media si no está sacando tilapia de una libra. Y eso tienes que darte cuenta si ya para el crecimiento todo ese esa camada tiene que irse para afuera, perfecto.
Speaker1: [00:04:45] ¿Y cómo se da cuenta usted que ya es para el crecimiento? Ya pasó un mes desde 5.º mes, meses.
Speaker2: [00:04:48] En el desarrollo, les vas viendo el tamaño y no aumentan el tamaño. Y entonces.
Speaker1: [00:04:53] Aquí está Managua
Speaker2: [00:04:53] Que algo paso.
Speaker1: [00:04:54] ¿Perfecto y usualmente por qué? ¿Qué les pasa a las tilapias?
Speaker2: [00:04:57] Que que bueno, nosotros tenemos aquí un amigo. Que nos visita. Es un lobo de agua. Una nutria.
Speaker1: [00:05:03] Ah, ya.
Speaker2: [00:05:04] Okay. Entonces, cuando él se lanza a la poza, las tilapias se asustan.

Speaker1: [00:05:09] ¿Y la han visto a él? Si la han grabado.
Speaker2: [00:05:11] No grabarle.
Speaker1: [00:05:12] No, no, pero.
Speaker2: [00:05:13] Pero si viene, sube y se bota acá y es grande.
Speaker3: [00:05:17] Ella viene por el río. Y como nosotros aquí abajo tenemos un túnel, ella entra por los perros, obviamente.
Speaker2: [00:05:24] Por el canal Río.
Speaker3: [00:05:25] Y salía por ese espacio que está ahí, algo serio. Se lanzaba a la poza y empezaba la cacería. Eso era.
Speaker1: [00:05:33] Una cacería del pobre quedándose.
Speaker3: [00:05:35] Tranquila, pero al ver eso se sentían amenazadas y se asustan.
Speaker1: [00:05:39] Claro.
Speaker3: [00:05:40] Deberían haberse infartado también y quedar muertas del susto. Entonces por eso la malla que pusimos para
Speaker1: [00:05:46] Un tremendo revolcón que hacer para cazar.
Speaker3: [00:05:48] Y como se remueve toda la suciedad que está sedimentos. Las energías buscaban oxígeno, se amontonaban en el chorro de agua, porque como estaba todo movido, entonces ellas iban a tratar de sobrevivir ahí por la.
Speaker2: [00:05:59] Vida, por el movimiento, porque no lo vas a encontrar en ningún libro.
Speaker1: [00:06:03] Bien y bien que nos dice es verdad, van a conseguir drinking star about the new ya no es about the Predators, les da pereza School like a River, looking de salmón vuelve a notebooks y le dice Ah, ok, ya está viendo Depredador is gonna be like scare in the tilapias stop growing em Van Dyke. Oh, yeah, Eso es something to you know Finding books. Ya, Ok. Si, si, si. Y es interesante porque la experiencia manda más que el libro. Gracias, amigo.
Speaker2: [00:06:49] Eso les puede servir.
Speaker1: [00:06:50] Amigo, muchísimas gracias. Ese dato, la verdad. Bueno, gracias. Gracias, Gracias. Muchas gracias. Chao.

Second recording

Speaker1: [00:00:00] Sí, súper. Bueno. A ver.
Speaker2: [00:00:02] Tienes dos tipos de tilapia la negra y la roja. La roja no tiene mercado aquí en el Tena. ¿La negra? Sí. Pero hay que tener mucho cuidado de la forma como se obtiene el alevines. Hay alevines que son manejados genéticamente mal y esos no desarrollan en el tiempo que tú tienes previsto. Entonces no se debe de comprar para para negocio. Nunca compres el alevín grande porque ese alevín ya está dañado. Tienes que comprar y adquirir el alevín, el más pequeñito.
Speaker1: [00:00:37] Ok. Eso dice Don South they don t have the red tilapias in the supermarket the right talking about that you like what kind of all, miss you are. Ok, because I say that. Somos muy difíciles de coordinar en Halloween. Ya.
Speaker2: [00:00:56] Esto es una cosa ahora, otra cosa que tienes que considerar es la alimentación de la tilapia. Cuando tú mantienes una alimentación a través de balanceado el desarrollo y el sabor de la carne es diferente a cuando tú utilizas complementos alimenticios como es el plátano, la yuca. La tilapia cambia de sabor.

Speaker1: [00:01:20] Y queda más sabrosa. Me imagino que.

Speaker3: [00:01:22] ¿Como lo de menos es como los pollos, no? Si les das el maíz al balanceado existe una gran diferencia, porque el rato que tú crías pollos con balanceado. No sé si te has dado cuenta de que que la carne es como que más babosa, pálida y hasta sabe muchas veces a pescado el pollo.
Speaker1: [00:01:43] En vez de.
Speaker3: [00:01:44] Pollo. En cambio, si tú les crías a los pollos con maíz, el grano de maíz es más criollo, o sea, es más natural de su comida. La carne es amarillenta, no es babosa y obviamente huele a pollo. Entonces idéntico es con la tilapia. O sea, si tú les crías solamente con balanceado y no haces este proceso de limpieza como en este momento que está ya en la fosa, el la tilapia, después con el tiempo empieza a dar un mal olor a lodo. Entonces por eso es muy importante el proceso que ahorita ya tiene una semana que está todo secándose y de ahí viene la desinfección que hacemos con Cal para matar todos los bichos.
Speaker1: [00:02:25] ¿Pero tengo una pregunta y dónde aprendió la tilapias?
Speaker2: [00:02:30] ¿Experiencia o veras existe la autoformación?
Speaker1: [00:02:35] Así es.
Speaker2: [00:02:36] Yo fui secretario de la Reserva de Biosfera del Tumaco perfecto y mantenía programas con gente de las diferentes comunidades además de producción, y dábamos asesoramiento técnico y entonces necesitábamos saber qué es lo que íbamos a hacer ahora mismo. Y dentro de eso salieron dos libros que los elaboró la GTZ y se entregó a las comunidades como una guía para el cultivo de las tilapias.
Speaker1: [00:03:05] Y esos libros están disponibles en la red
Speaker2: [00:03:08] Eso está en la red. Ya vas a encontrar.
Speaker1: [00:03:10] Dónde está el
Speaker2: [00:03:11] Consejo Provincial de aquí también publicó eso en la red, porque eso es elaborado por la GTZ, justamente por las experiencias de campo vividas. Claro, sí. Y de ahí mi esposa. Ella es técnica agropecuaria. Entonces.
Speaker3: [00:03:26] Bueno, nosotros en el colegio nos daban fue una parte de de una materia que tenía de piscicultura y ahí nos daban.
Speaker2: [00:03:33] ¿En qué colegio te graduaste?
Speaker1: [00:03:34] No soy de la Maximiliano, es técnico Industriales, No soy técnico.
Speaker2: [00:03:39] Industrial, aclara. Claro, la Paty es de
Speaker3: [00:03:42] La Pecuaria, pero es solamente bachiller.
Speaker2: [00:03:46] Claro, Mis hijos también se graduaron de la MAX. Ya el uno está en Yachay y el otro está en la Católica, en La Plata.
Speaker1: [00:03:53] Imagínese.
Speaker3: [00:03:55] Tengo un video que se te pase, el video me.
Speaker2: [00:03:57] Sale así.
Speaker1: [00:03:58] Puede pasarnos muchísimas gracias en Other Worlds. Yeah, yeah, yeah, yeah. Perdón. Perdón. ¿Me repites su nombre? Cuando le quiten el
Speaker3: [00:04:12] Uniforme, te quedas sin agua. Y me hace.
Speaker2: [00:04:15] Su nombre Si alguna vez llamaba. Y su hermana lo. Man algún ya. Nosotros tenemos aquí estudiantes de Ikea.
Speaker1: [00:04:29] Sí, eso le contaba a mi compañera Pablito.
Speaker2: [00:04:32] Y entonces.
Speaker1: [00:04:34] Ella.

A4.2 English summary commercial pond 3

Expert in tilapia farming.
Nr of tilapias: at the beginning 1200 tilapias, the result 800 (predators: birds, escape, and die)
Reason: commercial
Food: Balanceado, depending on the age
Size of the pool: (4 *9*1.6) m
Process:

- Buy the babies
- Raise it with different kind of balanceado (until the fish are 1.5 lbs)

Time required to grow them: 6 months
Water source: Natural river flow from headwaters (from where the water originates)
Kind of balanceado:

- Babies: growing up balanceado
- Young: fattening balanceado

What happens with the dirty water:

- 1 month (disinfection, cleaning process, with chemicals)
- 3 months the same
- 5 months the same
- Then when the fish are gone, and the water is out he treats the sediment and the soil

Distance to the river: ponds were 7m away from the branch of the Tena River

Extra comments

- Predators: birds and waterdogs (make turbulence and tilapia are scared of this)
- When the tilapias are afraid, they don't grow more → Some even die from heart attack
- When growing stops, stop feeding the tilapia, wasting money
- Just look at the size for growing
- Red tilapia not being farmed because not well received by people
- Buy the babies when they're really small, as small as possible
- Depending on what the tilapia eat (natural or balanceado) they will have a different taste
- Tilapia very invasive if they escape
- Tilapia from Africa and when it came here it spread out
- Family of piranha
- Tilapia is a huge predator
- Be careful when growing tilapia because they are predators so when they escape it's bad

A5. Personal pond 1

This interview was conducted on the 26th of November 2022. The interviewers were William Quezada and Iris Jonker. The interviewee was Martha Ollala. The coordinates of the tilapia farm and location of the interview are: -1.02163, -77.80590.

A5.1 Transcription interview personal pond 1

Speaker1: [00:00:00] Y doña Marthita en general, quisiéramos saber nosotros de más o menos de cuántas tilapias cree que tienen su piscinita para, para, para su consumo.
Speaker2: [00:00:11] De estar como unas 200 tilapias.
Speaker1: [00:00:13] Ya unas 200 tilapias, muy bien, unas 200. Y ustedes las hace para solamente para su consumo, por deporte, por el cine, más.
Speaker2: [00:00:22] Por deporte de la de las nuevas líneas.
Speaker1: [00:00:25] No.
Speaker2: [00:00:25] No hacemos parada para venta ni porque esa es una piscina especial, que es una vertiente, es una vertiente. Entonces el aprovechó y se la diariamente se les da de comer el.
Speaker1: [00:00:39] Alimento balanceado que venden en los.
Speaker2: [00:00:44] Mismos lugares de bien.
Speaker1: [00:00:47] Que yo hago productos de otros.
Speaker2: [00:00:50] Productos. Entonces lo que lo que se hace también es por ejemplo si salimos yo aquí en las de comer en la piscina, abajo, como no es con cemento, es tierra, crecen unos hongos. Claro, ya, y ellas consumen.
Speaker1: [00:01:06] ¿Esos son también ya más o menos de usted la estima de cuánto? ¿Por cuántos la piscina?
Speaker2: [00:01:13] Esa piscina tiene unos 20 por 25.
Speaker1: [00:01:18] ¿20 por 25 y de profundidad?
Speaker2: [00:01:20] De profundidad tiene un metro. Un metro y en otras tiene uno 20 y en otra unos 80 centímetros.
Speaker1: [00:01:27] Más o menos, en promedio, un metro de un metro. ¿Oiga, y cómo empieza el proceso de cribado de las tilapias? ¿Ustedes las compran alevines, las compran más? ¿Necesitas?
Speaker2: [00:01:37] Inicialmente nosotros los compramos en alevines, como no tenemos para vender, entonces ahora crecen y crecen naturalmente. Mire, ellos dicen que las tilapias que crecen naturalmente se vuelven pequeñas, pero no, las tilapias vuelven a su estado, o sea, del.
Speaker1: [00:01:57] Tamaño natural como deben ser. Así es. Y cuanto les toma más o menos a los alevines chiquitos crecer así hasta su tamaño, digamos, para que ya estén bonitas.
Speaker2: [00:02:06] Unos cuatro meses.
Speaker1: [00:02:07] Cinco meses ya. Muy bien, muy bien.
Speaker2: [00:02:11] Más la crianza de la ciudad.
Speaker1: [00:02:13] Ya. ¿Entonces usted me contaba que para suerte el agua que viene para la piscina viene de la vertiente, no?
Speaker2: [00:02:20] Sí, es una vertiente.
Speaker1: [00:02:21] Pucha, qué chévere. Entonces aprovecha directamente ahí no.
Speaker2: [00:02:24] Se lo saca contigo porque tampoco tenemos alcantarillado. Entonces las haga con tubos, los sacamos por acá.

Speaker1: [00:02:29] Sí, sí, claro, perfecto, claro. ¿Otra preguntita, el alimento balanceado que usted compra es el mismo siempre? ¿O tal vez va cambiando de balanceado? ¿Si son pequeñitas o más grandes?
Speaker2: [00:02:42] No son pequeñitas, Se les da el alimento de crianza.
Speaker1: [00:02:46] ¿Alimento de crianza?
Speaker2: [00:02:47] Yo pienso que es un más pequeñito.
Speaker1: [00:02:51] Como un polvito.
Speaker2: [00:02:51] Casi, y luego se les da ese engorde.
Speaker1: [00:02:54] A luego de engorde y ya yo.
Speaker2: [00:02:58] Le doy un poco mezclado porque no, no, no, no, no las tengo separadas.
Speaker1: [00:03:03] Ya los tengo en la misma, en la misma cosa, ya perfecto y ya entonces el proceso solamente les compro un alevines, les doy el de el de crianza, luego les doy el de engorde cuatro meses y acabamos. Me hizo doña Martita. Eso era todo lo que queríamos saber, la verdad es como le digo cosas ya de hundred and ok, ok.
Speaker3: [00:03:35] Pues gracias, muchas gracias doña Marthita.
Speaker1: [00:03:38] Oiga, de.

A5.2 English summary personal pond 1

Nr of tilapias: 200
Farming for family sport, for fun (?)
Food: balanceado
Size of the pool: 20 * 25 * 1 m
Process:

- Buy the babies
- Raise it with different kind of balanceado

Time required to grow them: 4 months
Water source: natural river flow close to the house
Kind of balanceado:

- Babies: growing up balanceado
- Young: fattening balanceado
- Then a mix of both

What happens with the dirty water: back to the river
Distance to the river: branch of the river is 4m from the ponds

A6. Personal pond 2

This interview was conducted on the 26th of November 2022. The interviewers were William Quezada and Iris Jonker. The interviewee was Lino Grefa. The coordinates of the tilapia farm and location of the interview are: : -0.973332, -77.848839

A6.1 Transcription interview personal pond 2

Speaker1: [00:00:00] El sindicato. Hace años que me dediqué a estudiar. Yo estudié en la universidad y ahí estoy, por ahí, pataleando y avanzando, avanzando. Bueno, como les

cuento una cosita, estamos haciendo lo que les digo. La investigación esta de las piscinas de aquí en la Amazonía. Y la compañera va a preguntarle un poquito de cuánto mide la piscina, cuánto tilapia hay aquí y cosas así de la piscina. Le pregunta a la compañera si puede grabarle la conversación para decir que usted cuesta una camiseta. No, solo grabar al audio box. Sí, sí. ¿El problema? Sí. ¿Cómo? Ya respétame, por favor. Ok, ya. ¿Verdad, compañero? Entonces, la cosa es que primero quedemos a ver si así esta piscina que usted tiene aquí es para su consumo, es de su familia o está vendiendo o qué hace con la tilapia que usted produce aquí.
Speaker2: [00:00:53] Somos.
Speaker1: [00:00:55] ¿La familia de la familia ya ustedes, la familia grande, entonces toca consumir tilapia, no? Porque sino tocar o comprar. Ya, ya, ya, ya. Y más o menos así en promedio. ¿Cuánta tilapia cree que tiene aquí, compañero?
Speaker2: [00:01:07] 200 están por ahí.
Speaker1: [00:01:08] ¿200 están aquí? Mmmm. Ya solo tilapia ahorita está ahí mismo acá chama y Tilapia. Ah, ya, ya. Muy bien, muy bien, muy bien. ¿Y más o menos usted que me dice que usted sabe desde la piscina cuánto mide la piscina así para usted? Más o menos en dimensiones. Yo le pongo cinco, 5%, cinco por cinco y de profundidad unos 50, 80, 80 centímetros, profundidad. Perfecto. Ya. ¿Y cuénteme un poquito de usted cómo cría las tilapias, de cómo les crían, cómo es el proceso desde que son chiquitos? ¿Usted compra alevines y compran alevines y de ahí qué hace? De cosas de crecimiento. ¿Cómo del proceso de crecimiento?
Speaker2: [00:01:49] Intentando comer balanceados como seres humanos. Desayuno, almuerzo y merienda. Ya de mañana a las 12 y tarde ya con.
Speaker1: [00:02:00] Puro balanceado, puro balanceado ya. ¿Y más o menos usted lo que cría tilapias, Cuánto tiempo cree que le tomará a la tilapia crecer desde alevines hasta grande?
Speaker2: [00:02:09] Hasta cuatro meses.
Speaker1: [00:02:10] ¿O cuatro meses? Ah, ya, ya. ¿Y en el proceso tú le das comida diferente o la misma balanceado? Siempre el mismo balanceado siempre.
Speaker2: [00:02:19] Hasta depende del crecimiento que van creciendo. Y luego va otro tipo de balanceados.
Speaker1: [00:02:24] ¿Vaya, cómo es eso? Eso, cuénteme, no el engorde. A ver, primero, primero cuál va el crecimiento, crecimiento.
Speaker2: [00:02:30] Luego el engorde y luego ahí pasa.
Speaker1: [00:02:33] Más o menos tú cuando empiezas a darle engorde, ya.
Speaker2: [00:02:36] Cuando a 20 centímetros ya están grandes.
Speaker1: [00:02:40] Ya ahí empieza a engordar el cuerpo. Perfecto compañero. Muy bien, muy bien, muy bien. ¿Hay alguna pregunta más de de dónde viene la agüita que usa para estar aquí?
Speaker2: [00:02:49] Una botellita de toma de Río Tolima, de.
Speaker1: [00:02:51] Acá a Riachuelo ya.
Speaker2: [00:02:53] Es un río natural, viene de arriba y tenemos con todos estos tubitos de agua.
Speaker1: [00:03:00] Viene directo de arriba. Pues también me hicieron el tubito, todo allá. Perfecto, ya, ahorita ya, ya, muy bien, entonces hay a ustedes les hace así del agua toma del río, entonces ellos comen más o menos y están usando siempre balanceado, dicen no, ya cambia, cambia de chiquitas, es de crecimiento y más grande engorde cuando ya de 20

centímetros dicen ya, ya, ya, muy bien, entonces allá otra pregunta más. El agua que viene de aquí viene del riachuelo y de aquí está aquí en el ahorita y de ahí que pase con el agua a donde va el agüita.
Speaker2: [00:03:34] Ahí tiene el resto.
Speaker1: [00:03:35] Agua es agua y de ahí va para el riachuelo y ya. Ah, ya. Bien, bien, ya compañeros, eso compañero, muchísimas gracias por su ayuda, pues muchas gracias por su colaboración. Así será. Ah, ya. Y ustedes iniciaron el proceso, hicieron la construcción y se produce poquito a poquito. Se produce mucha idea para un mito. Pucha, buenísimo, es perfecto. Eso sí que no sé si hay tercera producción ya.

A6.2 English summary personal pond 2

Nr of tilapias: 200 (tilapia + cachama)
Reason: family food source
Food: Balanceado
Size of the pool: (5 *5*0.8) m
Process:

- Buy the babies
- Raise it with different kind of balanceado

Time required to grow them:
Water source: Natural river flow that passes close to the house
Kind of balanceado:

- Babies: growing up balanceado
- Young: fattening balanceado

What happens with the dirty water: back to the river
Distance to the river: branch of the river was 10m from the ponds (using pipes to guide the water)

Appendix B: Questionnaire analysis results

Demographics

D1. Gender	Frequency N= 71	Percentage (%)
Male	30	42.25
Female	41	57.75
D2. Age	Frequency N= 71	Percentage (%)
< 30	10	14.08
30 – 40	23	32.39
40 – 50	14	19.72
50 – 60	14	19.72
60+	10	14.08
D3. Occupation	Frequency N= 71	Percentage (%)
Fishing	2	2.82
Tourism	4	5.63
Agriculture	13	18.31
Household chores	16	22.54
No occupation	4	5.63
Tilapia sector	0	0
Other	32	45.07
D4. Education level	Frequency N= 71	Percentage (%)
Elementary	12	16.90
High School	35	49.30
Third level degree	21	21
Fourth level degree	3	29.58
No education	0	0
Other	0	0
D5. Years in community	Frequency N= 71	Percentage (%)
< 11	16	22.53
11 – 15	6	8.45
16 – 20	10	14.08
21 – 25	1	1.41
26 – 30	6	8.45
30 +	32	45.07
D6. Ethnic background	Frequency N= 71	Percentage (%)
Indigenous	54	76.06
Mestizo	17	23.94
Afro – Ecuadorian	0	0
Other	0	0
D7. Years going to the river	Frequency N= 71	Percentage (%)
< 11	12	16.90
11- 15	4	5.63
16 – 20	2	2.81
21 – 25	2	2.81
26 – 30	6	8.45

30 +	45	63.38

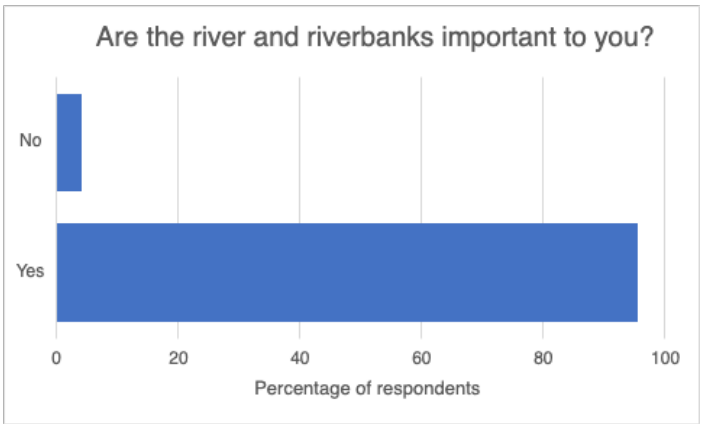

Figure 1. The percentage of respondents who think the river Tena and Pano and its riverbanks are or are not important

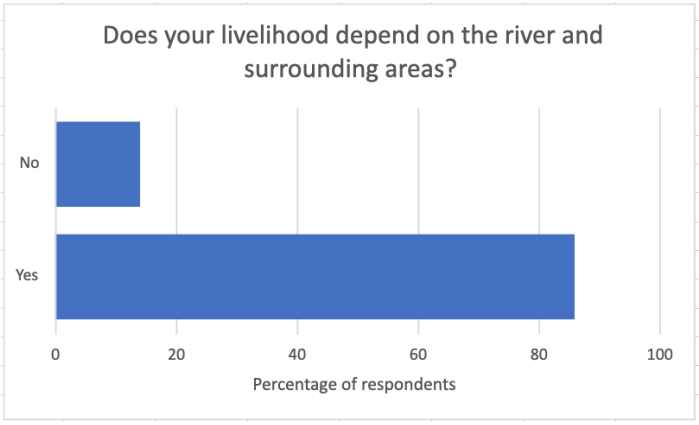

Figure 2. The percentage of respondents whose livelihood depends or does not depend on the river Tena and Pano and its riverbanks

Table 1: Correlation between dependence on Food provisioning and the ranking of Food provisioning. The correlations table shows there is a significant correlation between dependence on Food provisioning and the ranking of food provisioning since p < 0.05. It is a small correlation because the Pearson correlation value is between -0.1 and -0.29.

Correlations

		NS4. Indicate how dependent you are on the benefits provided by the river. – Providing food for people, native fish (carachama, viejas, etc)	NS3. Which benefits do you consider most important? Rank the benefits from 1 (most important) to 7 (least important). – Providing food for people, native fish (carachama, viejas, etc)
NS4. Indicate how dependent you are on the benefits provided by the river. – Providing food for people, native fish (carachama, viejas, etc)	Pearson Correlation	1	-.243*
	Sig. (2-tailed)		.041
	N	71	71
NS3. Which benefits do you consider most important? Rank the benefits from 1 (most important) to 7 (least important). – Providing food for people, native fish (carachama, viejas, etc)	Pearson Correlation	-.243*	1
	Sig. (2-tailed)	.041	
	N	71	71

*. Correlation is significant at the 0.05 level (2-tailed).

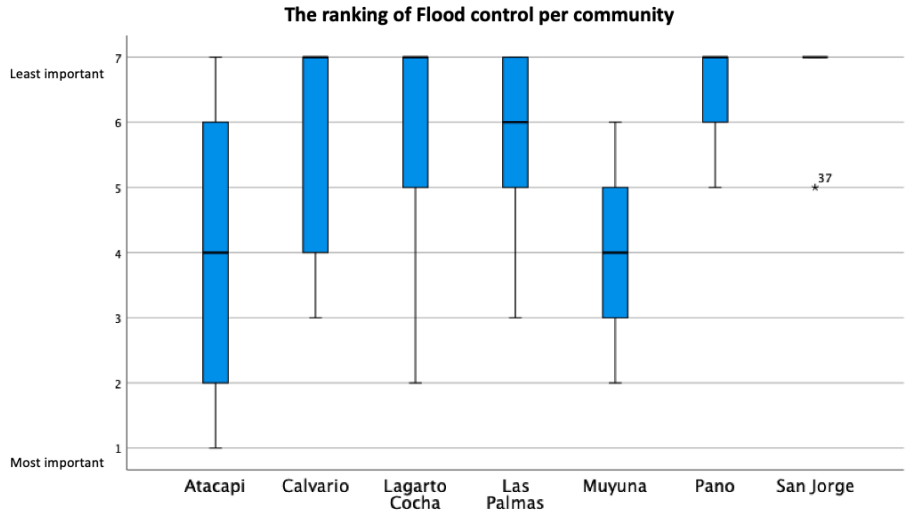

Figure 3: The ranking of Flood control related to the community of the respondent

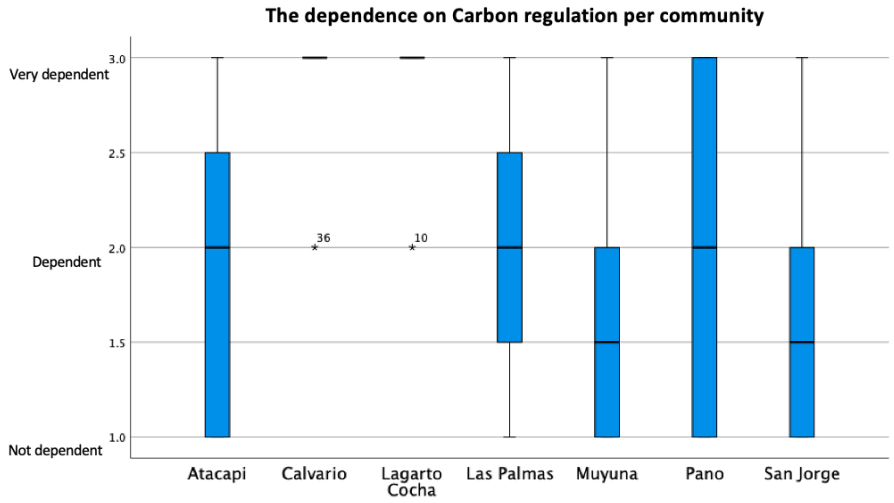

Figure 4: The ranking of Carbon regulation related to the community of the respondent

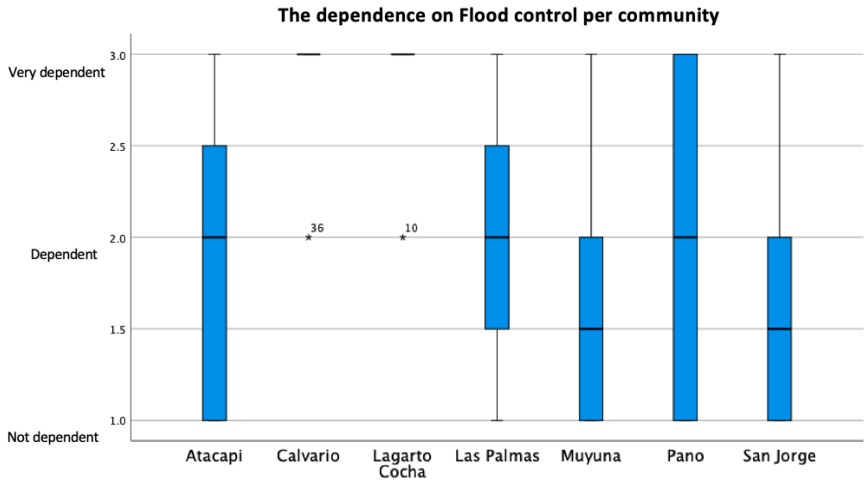

Figure 5: The ranking of Flood control related to the community of the respondent

Table 2: Correlation between dependence on flood control and the ranking of flood control. The correlations table shows there is a significant correlation between dependence on flood control and the ranking of flood control since p < 0.05. It is a medium correlation because the Pearson correlation value is between -0.3 and -0.49.

Correlations

		NS4. Indicate how dependent you are on the benefits provided by the river. – Flood control	NS3. Which benefits do you consider most important? Rank the benefits from 1 (most important) to 7 (least important). – Flood control
NS4. Indicate how dependent you are on the benefits provided by the river. – Flood control	Pearson Correlation	1	-.435**
	Sig. (2-tailed)		<.001
	N	71	71
NS3. Which benefits do you consider most important? Rank the benefits from 1 (most important) to 7 (least important). – Flood control	Pearson Correlation	-.435**	1
	Sig. (2-tailed)	<.001	
	N	71	71

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

Table 3: Overview of the additional benefits the respondents obtain from the river and riverbanks of the river Tena and Pano

EI2. Are there other benefits you get from the river and riverbanks?
To bathe
To bathe
To bathe
To bathe, feeling of happiness
To bathe, wash clothes, for cultivation, for consumption
Feeling of happiness
Wash clothes, to bathe, consumption of water
To bathe, wash clothes, irrigate crops
Water consumption
Water for consumption
to bathe, wash clothes
Wash clothes, to bathe
To bathe
Feeling of happiness and comfort
Feeling of joy and calm

Water consumption
Wash clothes
Water for consumption, to bath
Wash clothes, to bathe
Wash clothes
Water for consumption
Wash clothes
Wash clothes
Wash clothes
Wash clothes, bathe, water for cooking, water consumption
To bathe, sometimes wash clothes, consumption of water
To bathe
Wash clothes, to bathe, water consumption
To bathe
To bathe
To bathe
Wash clothes
Personal hygiene --> to bathe
Water for cooking
Water consumption, cooking, to bathe
To bathe
To clean/bathe
Wash clothes, to bathe
To cool down
Water consumption
Vital element for life
Water source for cooking and consumption

Table 4: Overview of the additional comments made by respondents throughout surveying

There is corruption from the government because they provide money to tilapia farmers even though they know it is bad (Lagarto Cocha, Lisbeth Tapuy, 10/12/22)
Would like to move to another place but not possible because of money, hasn't been going to the river for 8 years because of contamination (Lagarto Cocha, Bartolo Tapuy, 10/12/22)
The big ponds do not receive financial and institutional support but the small ponds in Kichwa communities do (Pano, Franklin Tapuy, 11/12/22)
Tilapia used to not be a part of our culture but now it is. (Atacapi, 12/12/22)
Positive effect of tilapia farming, economic benefits (Calvario, 15/12/22)
Positive effect of tilapia farming, economic benefits (Muyuna, 15/12/22)
Dependent on stone walls (gaviones) for protection against floods (Muyuna, 15/12/22)
She is not dependent on the provisioning of fish by the river but it is important for her community (San Jorge, Nancy Quezada, 17/12/22)
Tilapia are predators and eat the other fish. The release of the wastewater from tilapia farms into nearby streams causes contamination. (San Jorge, 17/12/22)
Cultural identity is very related to the river for Kichwa people. He is looking to move to a place next to the river with less contamination, so further up the river. (San Jorge, César Grefa, 17/12/22)

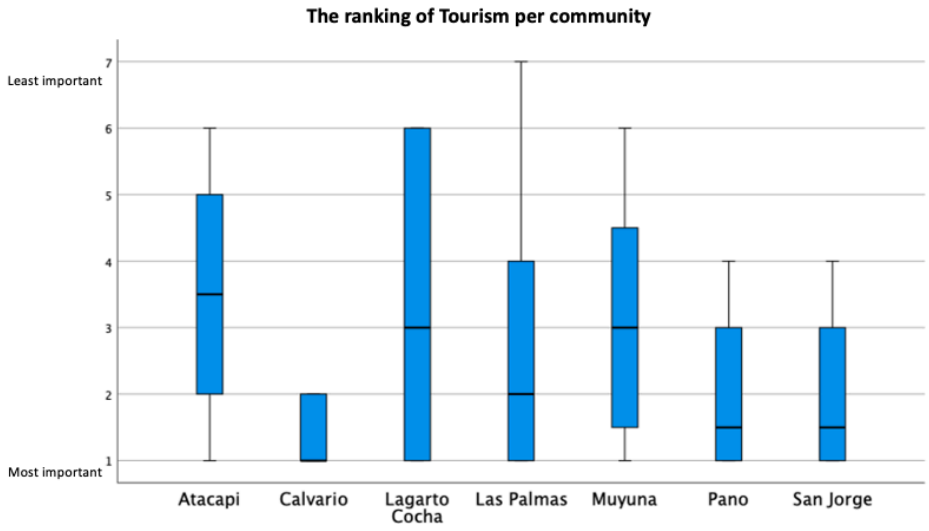

Figure 6: The ranking of Tourism related to the community of the respondent

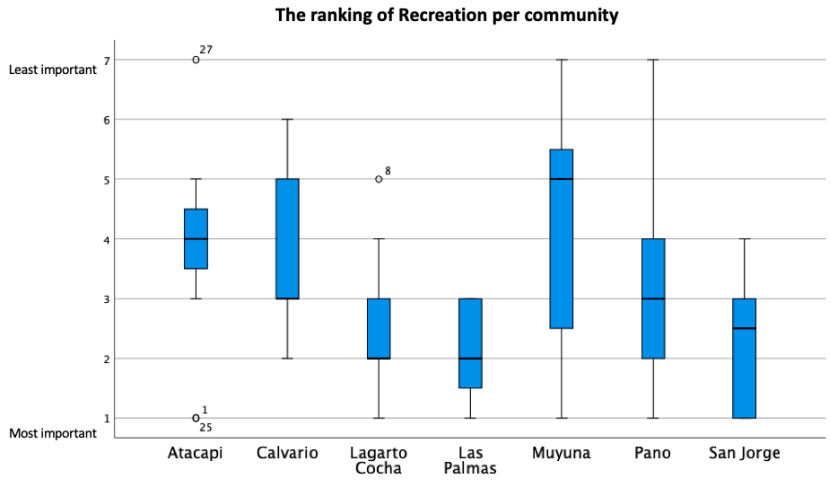

Figure 7: The ranking of the Recreation related to the community of the respondent

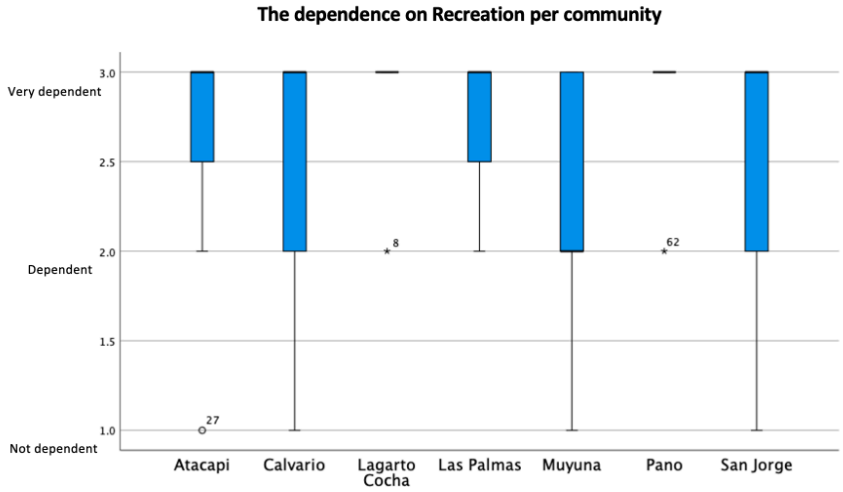

Figure 8: The dependence on Recreation related to the community of the respondent

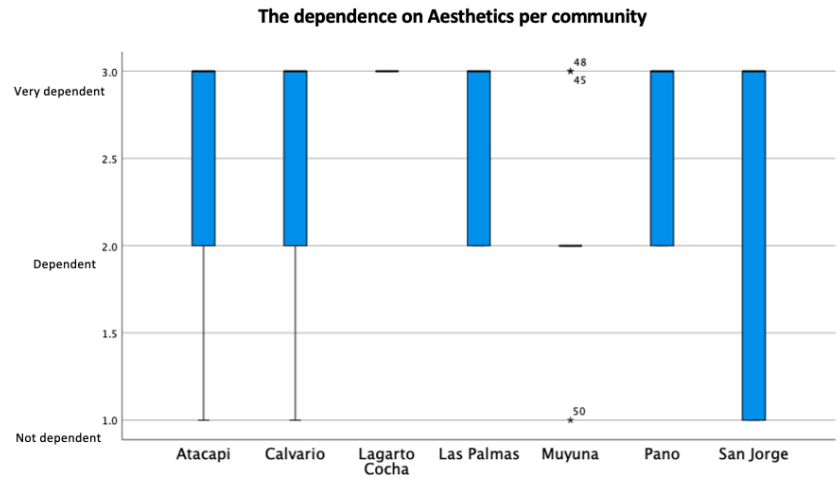

Figure 9: The dependence on Aesthetics related to the community of the respondent

Table 5: Correlation between dependence on tourism and the ranking of tourism. The correlations table shows there is a significant correlation between dependence on tourism and the ranking of tourism since p < 0.05. It is a small correlation because the Pearson correlation value is between -0.1 and – 0.29.

Correlations

		NS4. Indicate how dependent you are on the benefits provided by the river. – Tourism	NS3. Which benefits do you consider most important? Rank the benefits from 1 (most important) to 7 (least important). – Tourism
NS4. Indicate how dependent you are on the benefits provided by the river. – Tourism	Pearson Correlation	1	-.257*
	Sig. (2-tailed)		.031
	N	71	71
NS3. Which benefits do you consider most important? Rank the benefits from 1 (most important) to 7 (least important). – Tourism	Pearson Correlation	-.257*	1
	Sig. (2-tailed)	.031	
	N	71	71

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6: Correlation between dependence on recreation and the ranking of recreation. The correlations table shows there is a significant correlation between dependence on recreation and the ranking of recreation since p < 0.05. It is a small correlation because the Pearson correlation value is between -0.1 and smaller than -0.3.

Correlations

		NS4. Indicate how dependent you are on the benefits provided by the river. – Recreation (sport fishing, swimming)	NS3. Which benefits do you consider most important? Rank the benefits from 1 (most important) to 7 (least important). – Recreation (sport fishing, swimming)
NS4. Indicate how dependent you are on the benefits provided by the river. – Recreation (sport fishing, swimming)	Pearson Correlation	1	-.298*
	Sig. (2-tailed)		.012
	N	71	71
NS3. Which benefits do you consider most important? Rank the benefits from 1 (most important) to 7 (least important). – Recreation (sport fishing, swimming)	Pearson Correlation	-.298*	1
	Sig. (2-tailed)	.012	
	N	71	71

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7: An overview of specific problems respondents encountered related to tilapia farming

EI4. Did the implementation of tilapia farming result in any problems? If yes, in what problems?
Inconvenience. health problems
Skin fungus
Skin diseases

Skin fungus
Less tourism, skin problems, health problems on intimate parts
Skin diseases, river cannot be used when the water from the pools is released into the river
Health, a lot of waste
Loss of native fish, skin problems
Skin problems (brightens the skin), fungus on intimate parts (women)
Contamination
Health problems
Contamination of the river, skin problems, decreased flow of river
Skin problems, lung infections
Health problems: skin fungus and ear infections
Contamination of the water resulting in diseases for people
Health problems, less native fish
Skin problems
Contamination of the river, affects other fish species
Contamination due to balanceado
Fewer fish in the rivers
Contaminated water
Skin problems (white spots), tilapia are predators and eat the other fish
Chemical contamination
Cannot consume the water anymore, probably contaminated with chemicals
Contamination
Murky waters, irritations on the skin of children
Cannot swim in the river anymore
Contamination
Contamination of the river, the children get sick from the contaminated water, loss of native species
Contamination
Contamination, murky waters
Use of chemicals, social effects
"Disminucion caudal?", loss of native fish species

Skin health problems
Environmental destruction
Decline of native fish, contamination
Diseases
Colder water (stratification), health problems
Environmental pollution
Contamination of the rivers from "balanceado" food
Solid waste, predators
Loss of fishing source, cultural loss
Contamination --> infections
All the problems, contamination
many disruptions in the environment
Contamination
Contamination
Contamination -> skin problems
Health problems (skin). Children go swimming in the river and get white spots on their skin
Skin diseases
If filters are used there is no problem

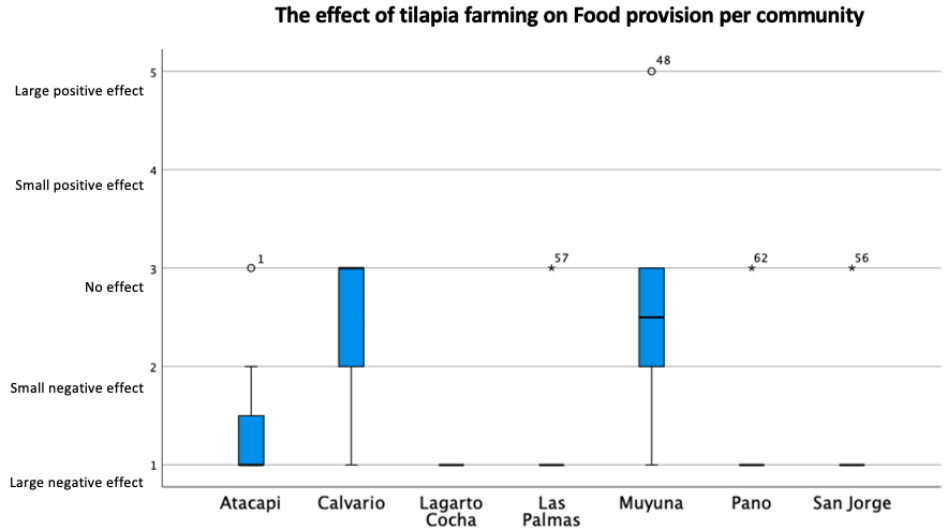

Figure 10: The (observed) effect of tilapia farming on provisioning of food related to the community of the respondent

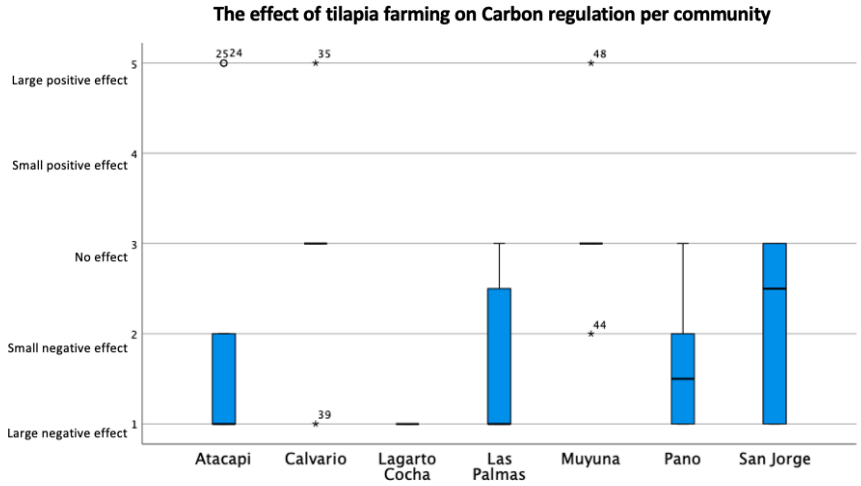

Figure 11: The (observed) effect of tilapia farming on carbon regulation related to the community where the respondent lives

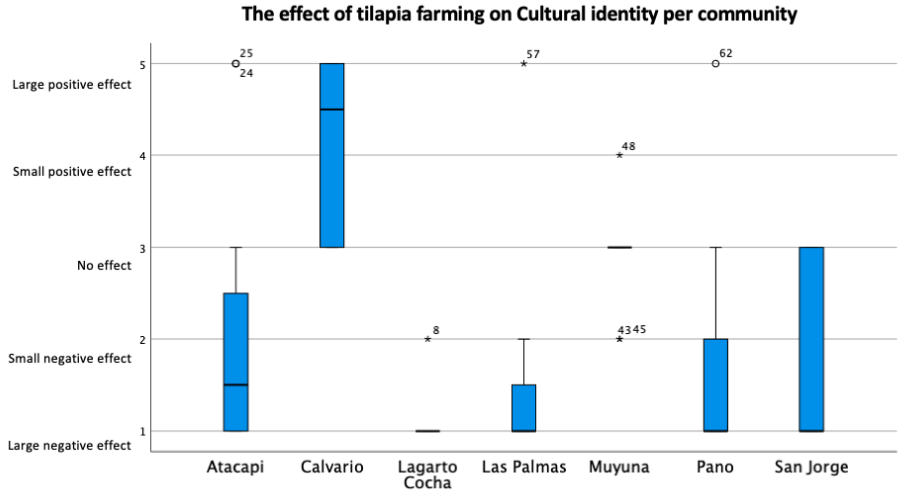

Figure 12: The (observed) effect of tilapia farming on cultural identity related to the community where the respondent lives

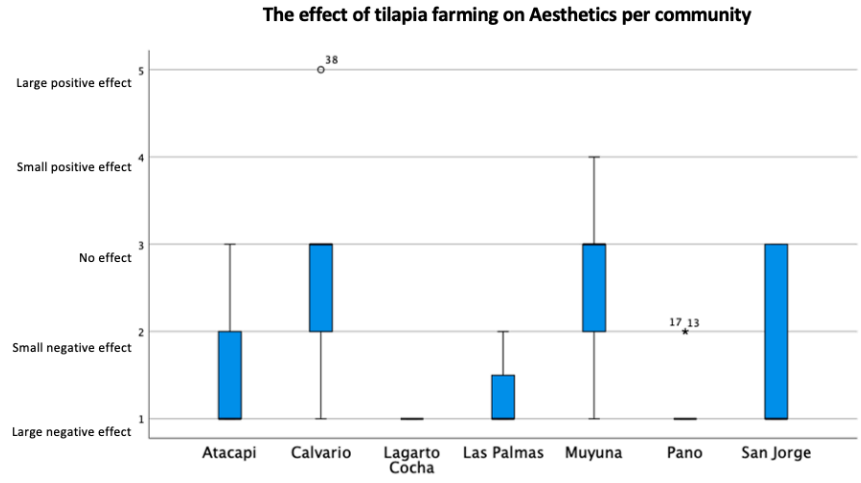

Figure 13: The (observed) effect of tilapia farming on aesthetics related to the community where the respondent lives

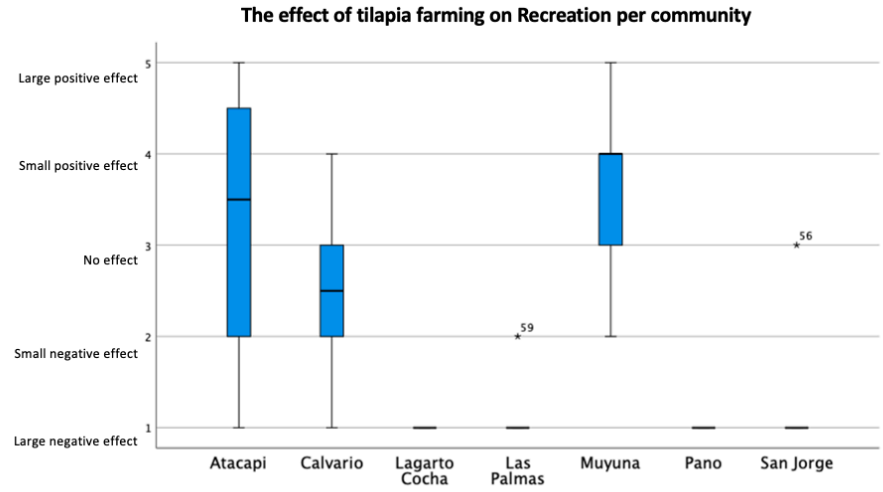

Figure 14: The (observed) effect of tilapia farming on recreation related to the community where the respondent lives

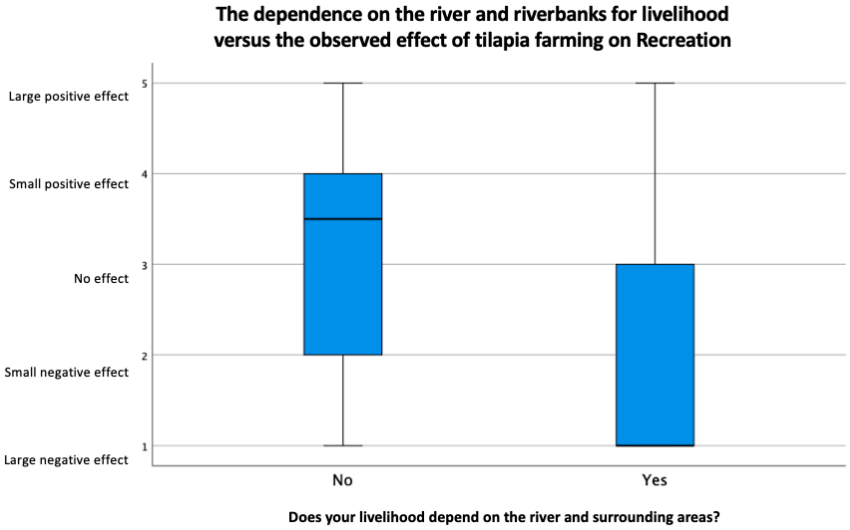

Figure 15: The (observed) effect of tilapia farming on recreation related to the dependence on the river and surrounding areas for their livelihood

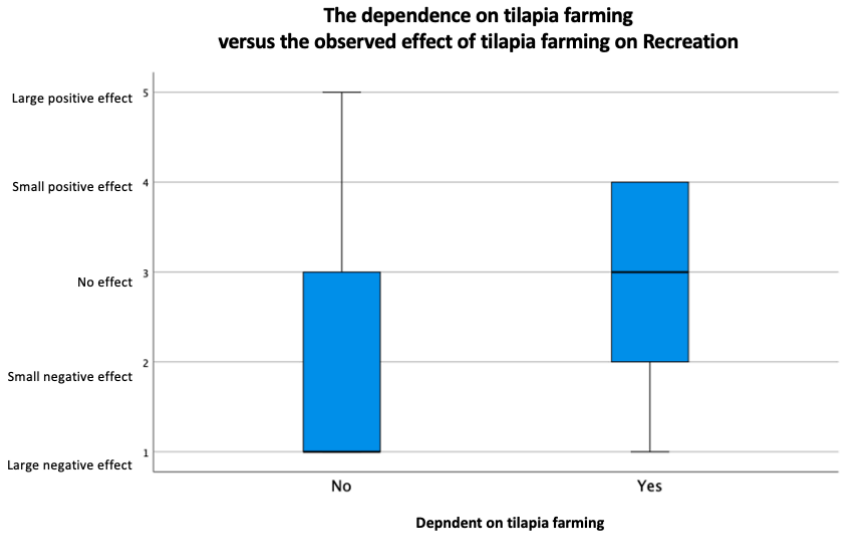

Figure 16: The (observed) effect of tilapia farming on recreation related to the dependence on tilapia farming

Table 8: Correlation between dependence on recreation and the observed effect of tilapia farming on recreation. The correlations table shows there is a significant correlation between dependence on recreation and the observed effect of tilapia farming on recreation since p < 0.05. It is a small correlation because the Pearson correlation value is higher than -0.1 and lower than -0.3

Correlations

		NS4. Indicate how dependent you are on the benefits provided by the river. – Recreation (sport fishing, swimming)	EI1. Indicate for the benefits below how they have been affected since the introduction of tilapia farming – Recreation (sport fishing, swimming)
NS4. Indicate how dependent you are on the benefits provided by the river. – Recreation (sport fishing, swimming)	Pearson Correlation	1	-.296*
	Sig. (2-tailed)		.012
	N	71	71
EI1. Indicate for the benefits below how they have been affected since the introduction of tilapia farming – Recreation (sport fishing, swimming)	Pearson Correlation	-.296*	1
	Sig. (2-tailed)	.012	
	N	71	71

*. Correlation is significant at the 0.05 level (2-tailed).

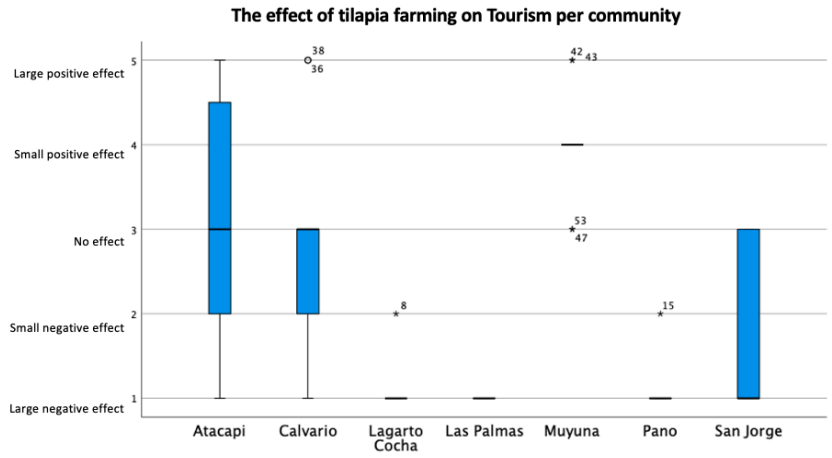

Figure 17: The (observed) effect of tilapia farming on tourism related to the community where the respondent lives

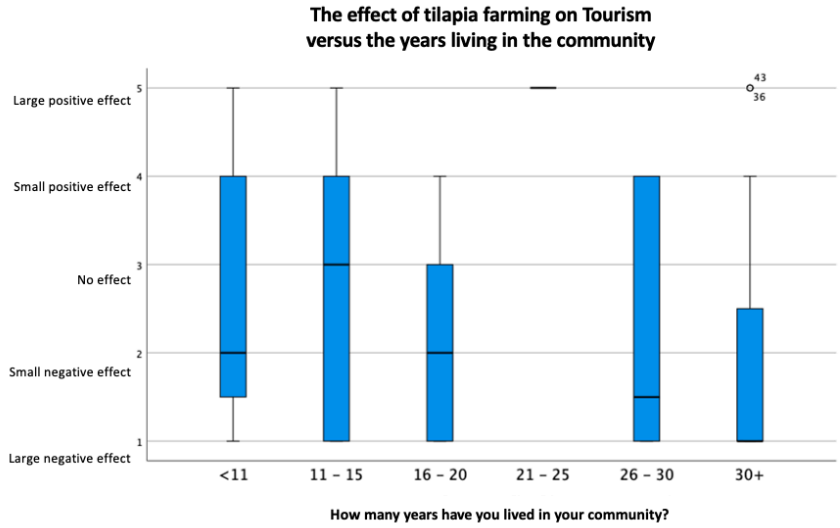

Figure 18: The (observed) effect of tilapia farming on tourism related to the years lived in the community

Table 9: Correlation between dependence on tourism and the observed effect of tilapia farming on tourism. The correlations table shows there is a significant correlation between dependence on tourism and the observed effect of tilapia farming on tourism since p < 0.05. It is a medium correlation because the Pearson correlation value is between -0.3 and - 0.49

Correlations

		NS4. Indicate how dependent you are on the benefits provided by the river. – Tourism	EI1. Indicate for the benefits below how they have been affected since the introduction of tilapia farming – Tourism
NS4. Indicate how dependent you are on the benefits provided by the river. – Tourism	Pearson Correlation	1	-.318**
	Sig. (2-tailed)		.007
	N	71	71
EI1. Indicate for the benefits below how they have been affected since the introduction of tilapia farming – Tourism	Pearson Correlation	-.318**	1
	Sig. (2-tailed)	.007	
	N	71	71

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

Table 10: Overview of the suggestions from the respondents concerning the improvement of tilapia farming

FM4. Do you have suggestions that could improve the farming of tilapia?
Stop farming
Improve the location of the pools, further from the river
Wastewater treatment
Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Collection and treatment of the wastewater
Going into dialogue with parties involved
Talking with all stakeholders about the problem, education, water treatment
Socialize the problem (talk more about it with parties involved), add oxidation tank, water treatment
That the pools are not connected to the river or close to the river
Request the intervention from the authorities to control the tilapia breeding
Water treatment
Wastewater treatment, to talk about the issue (socialize it)
Regulation of the discharge into the river
Filter nutrients from the water and recycle them to avoid contamination of the river
Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Economical support
Economical support
Financial support to community members
Economical support
Economical support
Institutional support - practices to farm tilapia
Reduce chemical food for tilapias, more natural food
Support and technical training/education for tilapia farmers
Provide knowledge/education of sustainable practices
Not use so much balanceado, use natural food for the tilapia like yuca

Institutional support
Only tilapia farms for personal use
Small farming --> only family, not commercial
Natural food for the tilapia (termites), no balanceado
Planting plants on the edge of the river, no littering, no use of chemicals, farmers need to have training/education
Separate the tilapia pools from the banks, minimise contamination, organic food, carry out controls
Improve feeding, move tilapia pools away from the river
Look for a foundation to have benefits and export
The water should not be contaminated
Extension of tilapia pools
Improve the pool design
Raise the tilapia in places far from the community or rivers
Control the commercial farming of tilapia
Not discharging the water from the farms directly into the river, find solutions against the contamination
Incentive to farm native fish or farm tilapia without using balanceado as food
Have more health control, use natural foods for the tilapia
Feed the tilapias with food from the area (cassava leaf or Chinese potato)
Wastewater treatment before it goes into the river
Prior control of the pools
Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Create employment in other companies --> productive matrix change
Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Get the pools away from the river and communities
Wastewater treatment (PTAR)
Tilapia ponds away from the river
Wastewater treatment (PTAR)

Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Wastewater treatment (PTAR)
Treatment of the wastewater (PTAR) before being released into the river
Remove the tilapia pools, wastewater treatment (PTAR)
Infrastructure - filters
Take precautions against contamination of the river
Export the tilapia to other countries, use filters in the farming process for the wastewater

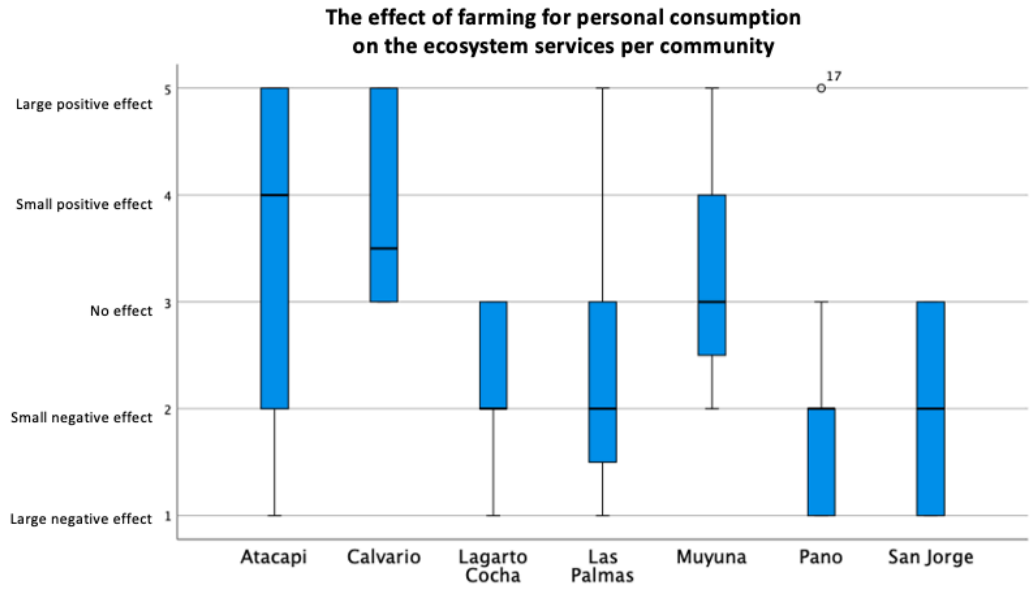

Figure 19: The effect of farming for personal consumption on the ecosystem services per community

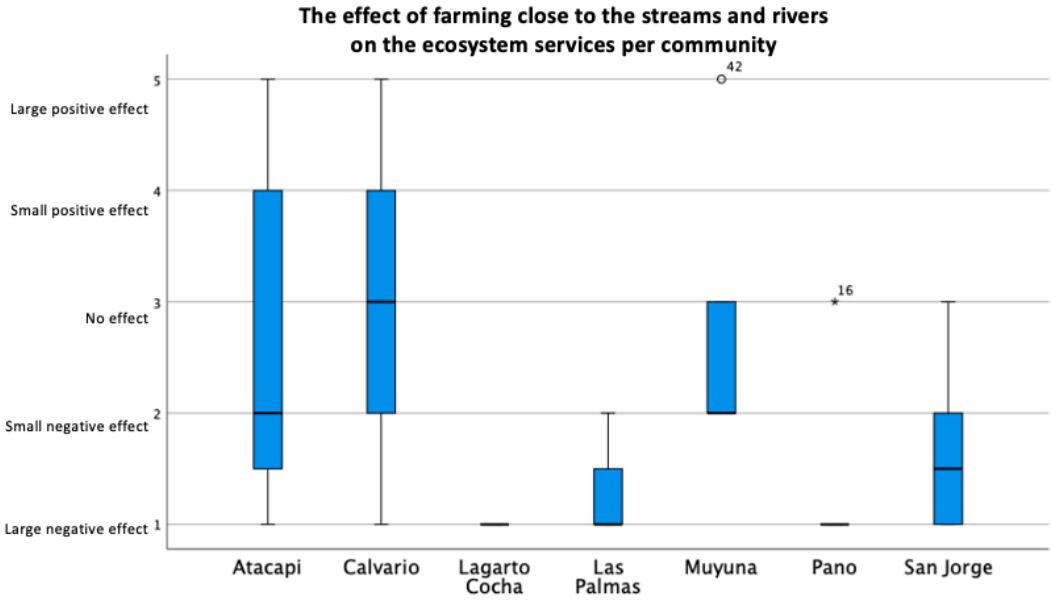

Figure 20: The effect of farming close to the streams and rivers on the ecosystem services per community

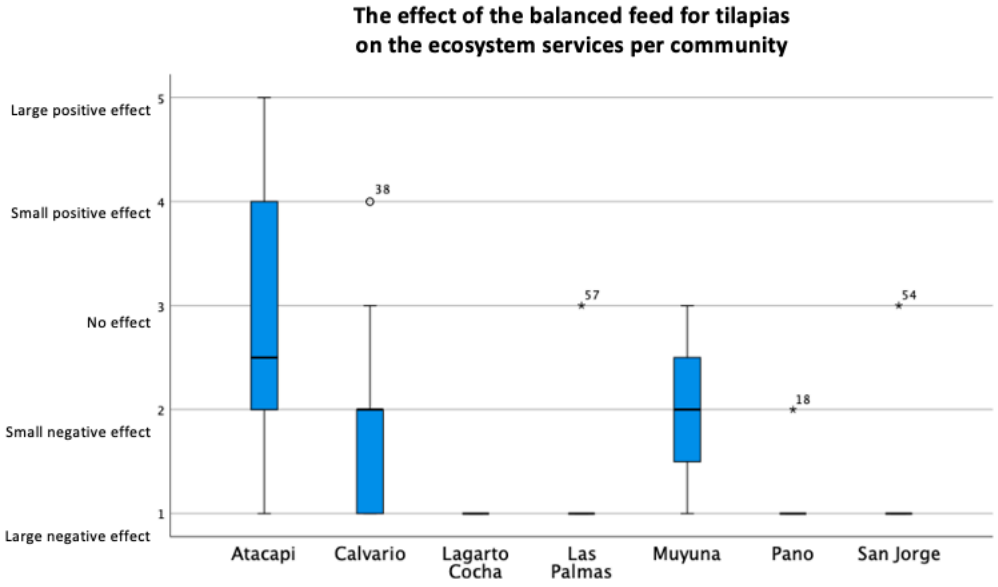

Figure 21: The effect of the balanced feed that is given to the tilapias on the ecosystem services per community

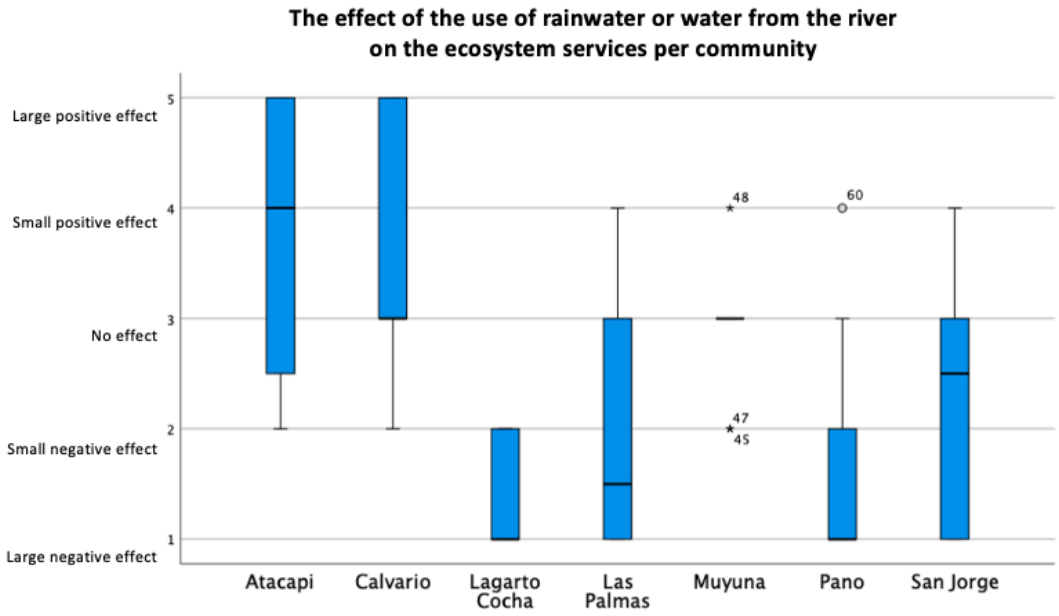

Figure 22: The effect of the use of rainwater or water from the river for farming on the ecosystem services per community

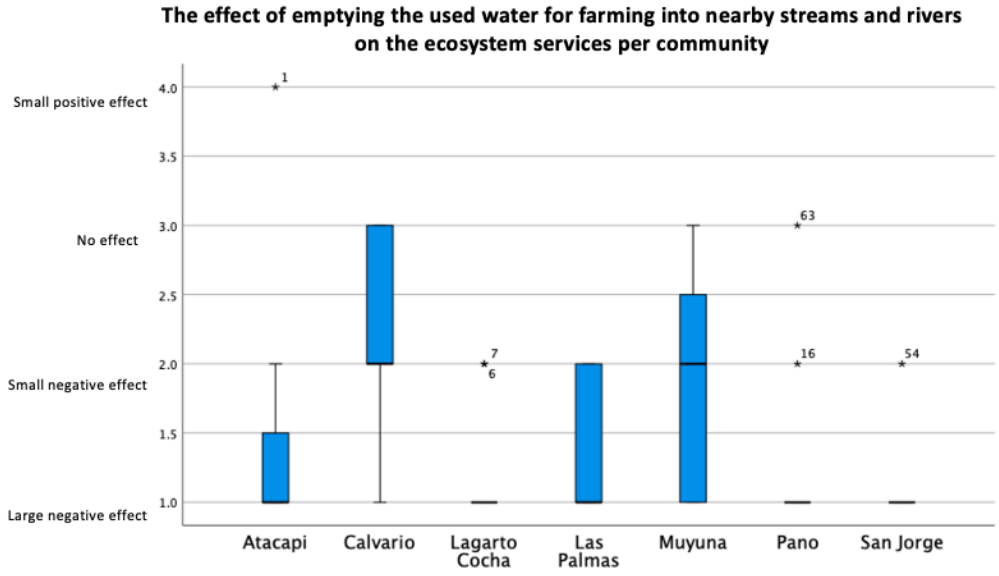

Figure 23: The effect of emptying the used water for farming into nearby streams on the ecosystem services per community

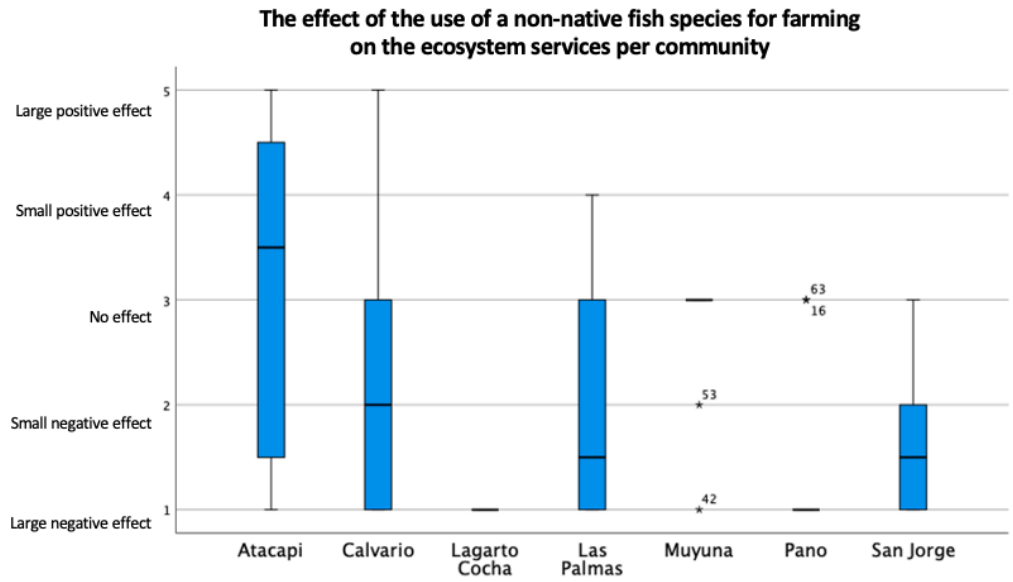

Figure 24: The effect of the use of a non-native fish species for farming on the ecosystem services per community

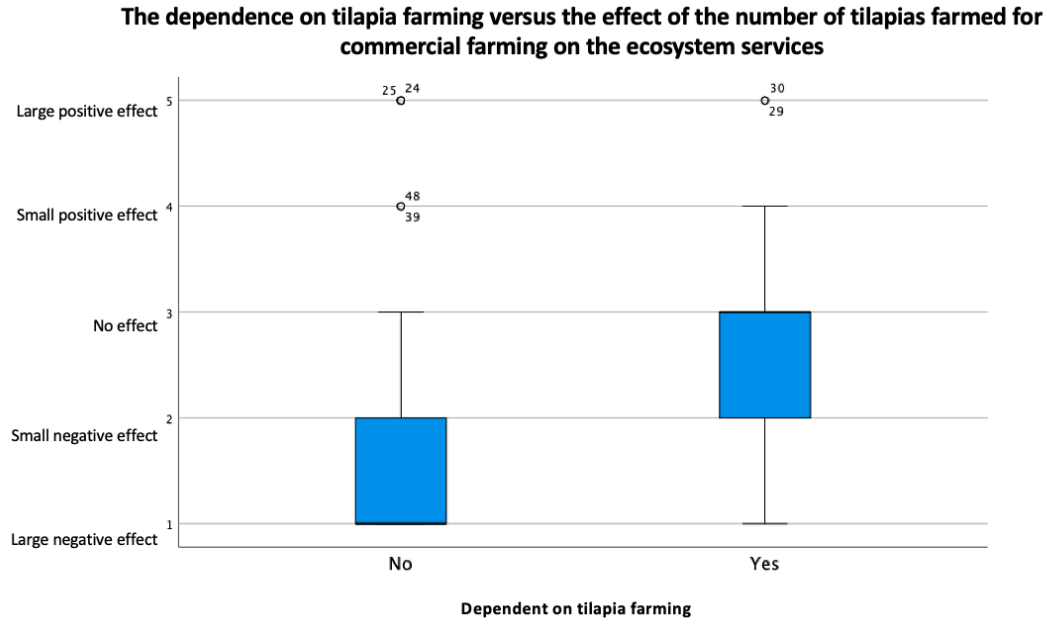

Figure 25: The effect of the number of tilapias farmed for commercial farming on the ecosystem services related to the dependence on tilapia farming

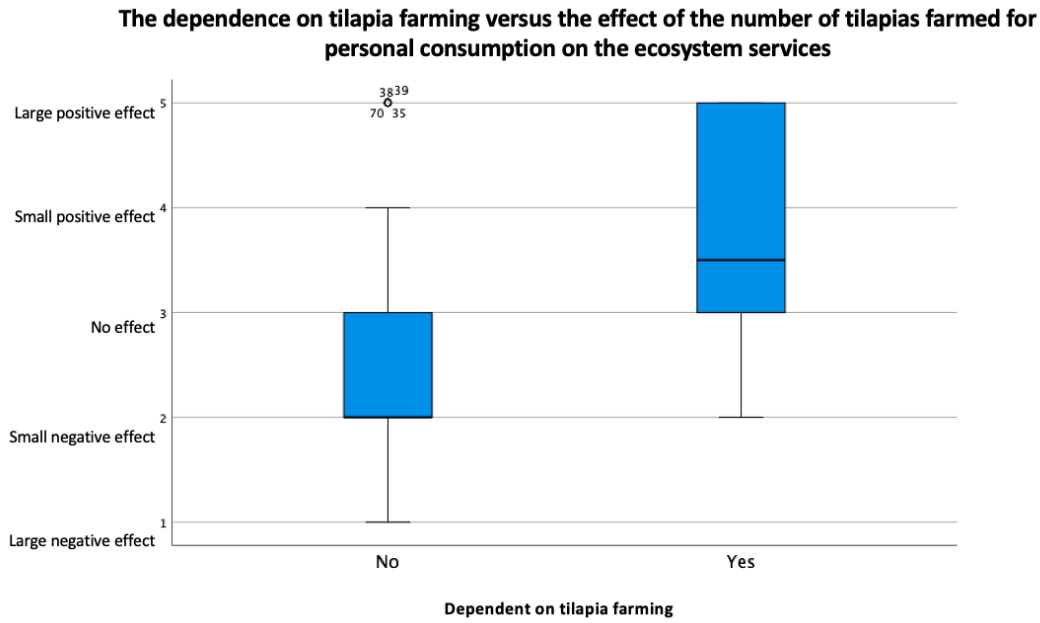

Figure 26: The effect of the number of tilapias farmed for personal consumption on the ecosystem services related to the dependence on tilapia farming

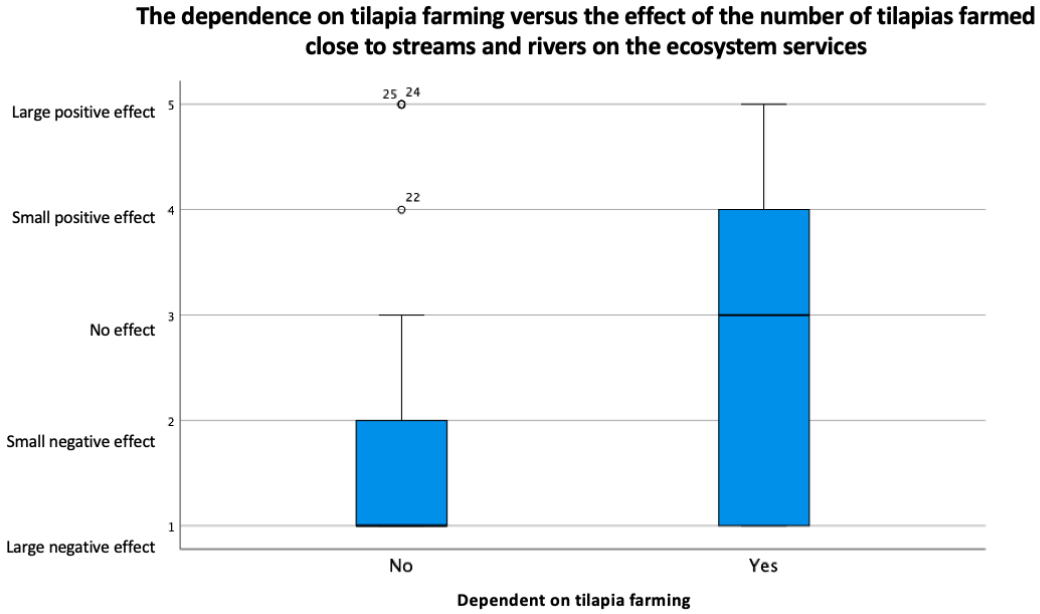

Figure 27: The effect of the tilapias farmed close to the river on the ecosystem services related to the dependence on tilapia farming

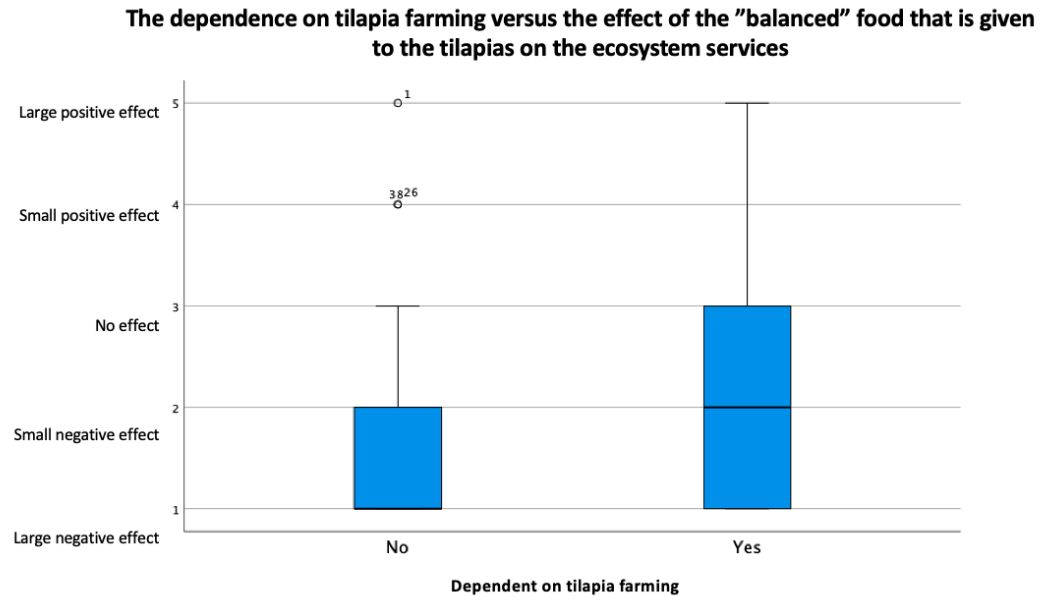

Figure 28: The effect of the food given to the tilapias on the ecosystem services related to the dependence on tilapia farming

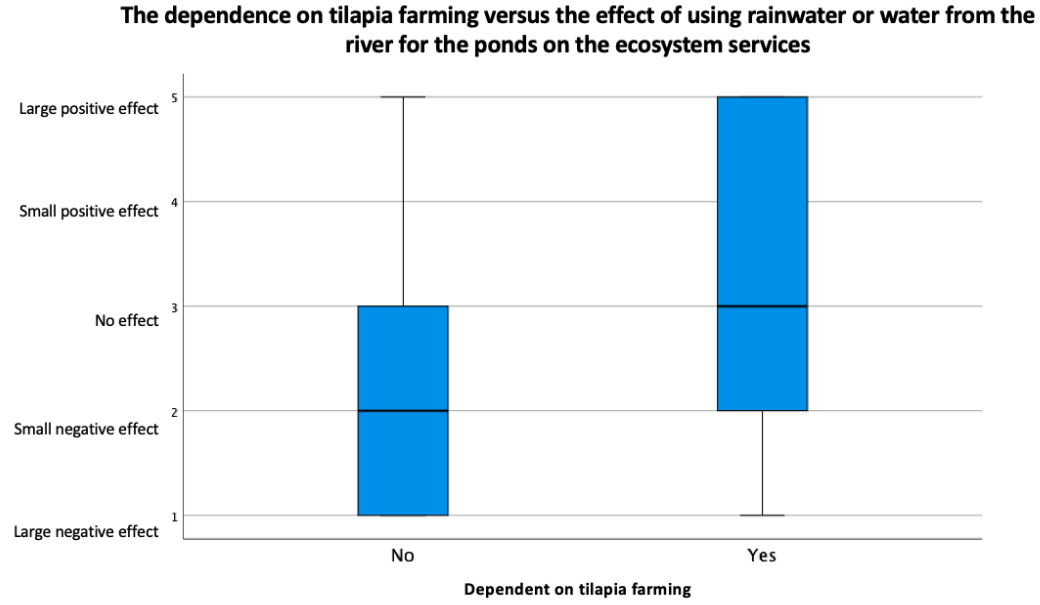

Figure 29: The effect of the use of rainwater or water from the river for farming on the ecosystem services related to the dependence on tilapia farming

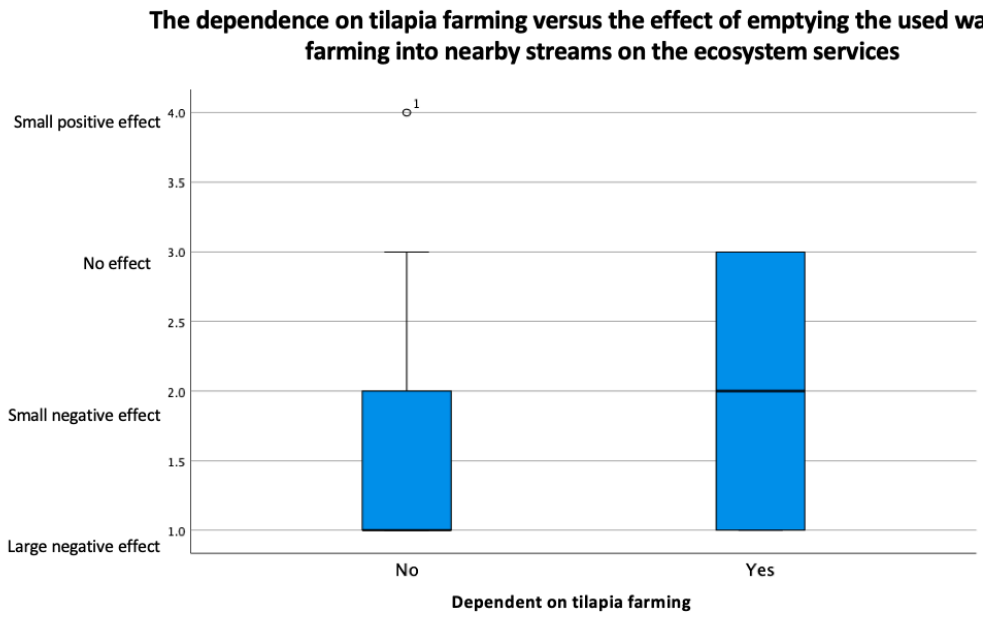

Figure 30: The effect of the emptying of used farming into nearby streams on the ecosystem services related to the dependence on tilapia farming

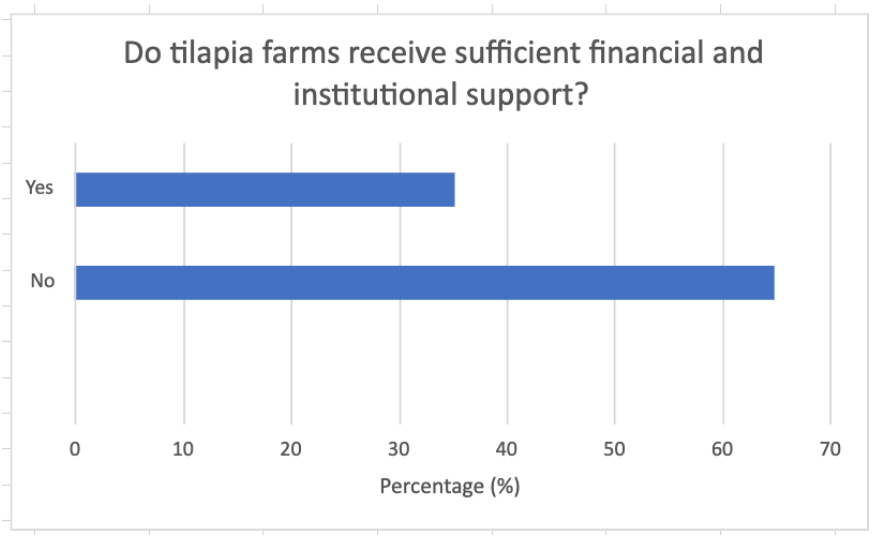

Figure 31: Overview of the response to the question if the tilapia farms receive enough financial and institutional support

Appendix C: Questionnaire

Survey Tilapia Farming
We appreciate your insight and your time. Your answers are anonymous and will be used to investigate the perceptions of local communities on tilapia farming.

1.Demographics

D1. What is your gender?
O Male
O Female
O Other

D2. What is your age?
O <30 O 50 - 60
O 30 – 40 O 60+
O 40 – 50

D3. What is your current occupation?
O Fishing
O Tourism
O Agriculture
O Household chores
O No occupation
O Tilapia sector: _____
O Other: _____

D4. What is your level of education?
O Elementary
O High school
O Third level degree
O Fourth level degree
O No education
O Other: _____

D5. How many years have you lived in your community?
O <11 O 11 - 15 O 16 - 20 O 21 - 25 O 26 - 30 O 30+

D6. Which ethnic background do you consider yourself?
O Indigenous O. Mestizo
O Afro – Ecuadorian O Other: _____

D7. How many years have you been going to the river (river Tena and river Pano) for activities such as fishing and swimming?
O <11 O 11 - 15 O 16 - 20 O 21 - 25 O 26 - 30 O 30+

2. Nature Service Questions

NS1. Are the river and the riverbanks important to you?
O No
O Yes

NS2. Does your livelihood depend on the river and surrounding areas?
O No
O Yes

The following questions are about benefits that people receive from nature, in this case the river and riverbanks. Both direct benefits and indirect benefits. Examples are fish that we get from the river for food or a place to swim for example.

NS3. Which benefits do you consider most important? Rank the benefits on the next page from 1 (most important) to 7 (least important).

Service	Ranking
Providing food for people, native fish (carachama, viejas, etc)	
Regulation of the carbon cycle	
Flood control	
Cultural identity*	
Aesthetics	
Recreation (sport fishing, swimming)	
Tourism	
Other: _____	

*With cultural identity we mean how the river and riverbanks contribute to your culture.

NS4. Indicate how dependent you are on the benefits provided by the river.

Not dependent 0 Dependent 1 Very dependent 2

Service	Dependency		
Providing food for people, native fish (carachama, viejas, etc)	0	1	2
Regulation of the carbon cycle	0	1	2
Flood control	0	1	2
Cultural identity	0	1	2
Aesthetics	0	1	2
Recreation (sport fishing, swimming)	0	1	2
Tourism	0	1	2

3. External influence Questions

The following questions are about the effect of tilapia farming on the benefits from the river and riverbanks since the introduction of tilapia farming.

Big negative effect 1 **Small negative effect** 2 **Doesn't affect** 3 **Small positive effect** 4 **Big positive effect** 5

EI1. Indicate for the benefits below how they have been affected since the introduction of tilapia farming					
Providing food for people, native fish (carachama, viejas, etc)	1	2	3	4	5
Regulation of the carbon cycle	1	2	3	4	5
Flood control	1	2	3	4	5
Cultural identity*	1	2	3	4	5
Aesthetics	1	2	3	4	5
Recreation (sport fishing, swimming)	1	2	3	4	5

Tourism	1	2	3	4	5

*With cultural identity we mean how the river contributes to your culture and we want to know if tilapia farming has had an effect on this.

EI2. Are there other benefits you get from the river and riverbanks?

EI3. If yes, how have these benefits been affected since the introduction of tilapia farming (from large negative effect to large positive effect)?

_____

EI4. Did the implementation of tilapia farming result in any problems? If yes, in what problems?

_____

EI5. Are you dependent on tilapia farming?
O No
O Yes

EI6. Have you had to move because of tilapia farming?
O No
O Yes

4. Drivers Questions

Big negative effect Small negative effect Doesn't affect Small positive effect Big positive effect
1 2 3 4 5

C1. Indicate how you think the following management practices affect the benefits people get from the river					
The number of tilapias farmed for commercial farming	1	2	3	4	5
The number of tilapias farmed for personal consumption	1	2	3	4	5
The tilapia farmed close to streams and rivers	1	2	3	4	5
The "balanced" food that is given to the tilapias	1	2	3	4	5
Using rainwater or water from the river for the ponds	1	2	3	4	5
Emptying the used water for farming into nearby streams	1	2	3	4	5
The use of a non-native fish species for farming	1	2	3	4	5

5. Future management Questions

FM1. What are current/future threats for tilapia farms in your area?
O Pollution
O Disease
O Climate change
O Other: _____

FM2. Are tilapia farms sufficiently protected against these threats?
O No
O Yes

FM3. Do tilapia farms receive sufficient financial and institutional support?
O No
O Yes

FM4. Do you have suggestions that could improve the farming of tilapia?

Name of the community	